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THE EVOLUTION OF MAN

A Series of Lectures Delivered under the Auspices of the Yale Chapter of Sigma Xi during the Academic Year 1921-1922

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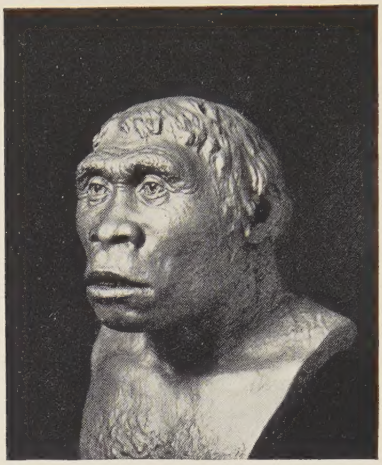
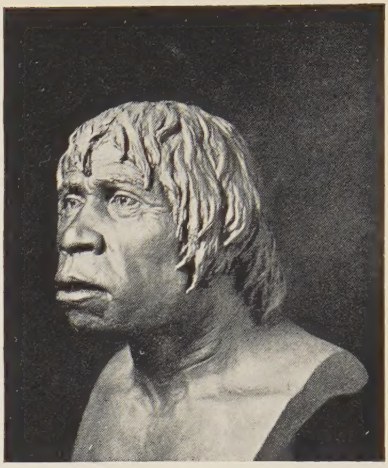
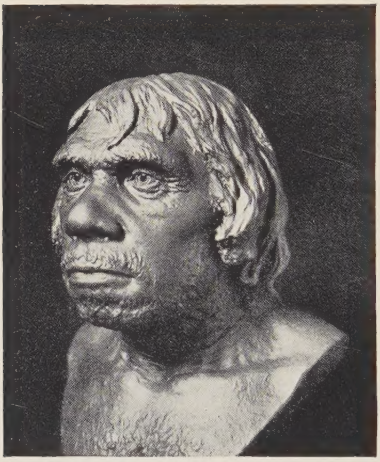


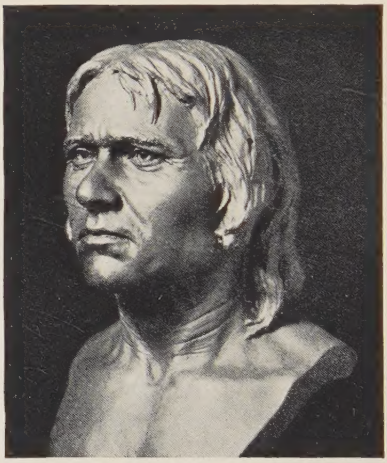
JAVA MAN
Pithecanthropus erectus.



PILTDOWN MAN
Eoanthropus dawsoni.



NEANDERTAL MAN
Homo neandertalensis.



CRÔ-MAGNON MAN
Homo sapiens.

Heads modelled by Professor J. H. McGregor, on his restorations of skulls of ancient types of man. These types are not stages in a single evolutionary line, but probably represent four divergent lines. Original models in the American Museum of Natural History, New York.

The Evolution of Man

By
Richard Swann Lull
Harry Burr Ferris
George Howard Parker
James Rowland Angell
Albert Galloway Keller
Edwin Grant Conklin

Edited by
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CONTENTS

		PAGE
Preface	GEORGE ALFRED BAITSELL	ix
Chapter I. The Antiquity of Man	RICHARD SWANN LULL	1
Chapter II. The Natural History of Man	HARRY BURR FERRIS	39
Chapter III. The Evolution of the Nervous System of Man	GEORGE HOWARD PARKER	80
Chapter IV. The Evolution of Intelligence	JAMES ROWLAND ANGELL	103
Chapter V. Societal Evolution	ALBERT GALLOWAY KELLER	126
Chapter VI. The Trend of Evolution	EDWIN GRANT CONKLIN	152
Bibliography		185
Index		191

ILLUSTRATIONS

Models, by Professor J. H. McGregor, of the heads of prehistoric types of man . . . . . *Frontispiece*

Fig. 1. Skulls from La Chapelle-aux-Saints, representing Neandertal man, and Grotte des Enfants, representing Crô-Magnon man . . . . . *facing page* 1

Fig. 2. Map to illustrate the broader lines of dispersal of the principal races of man. After Matthew 6

Fig. 3. *Pithecanthropus erectus.* Skull and face 15

Fig. 4. *Homo* (*Paleanthropus*) *heidelbergensis.* Mandible compared with that of a modern European. After Schoetensack 17

Fig. 5. *Eoanthropus dawsoni* (Piltdown man). Skull and face 21

Fig. 6. Skeleton of Neandertal man compared with that of Crô-Magnon man 25

Fig. 7. *Homo* (*Paleanthropus*) *neandertalensis.* Skull and face 27

Fig. 8. *Homo rhodesiensis.* Skull and face 29

Fig. 9. *Homo sapiens* (Crô-Magnon man). Skull and face . 33

Fig. 10. Provisional phylogeny of man and the anthropoids . 36

Fig. 11. Fertilization of the ovum 41

Fig. 12. Four diagrams of early human embryos . *facing page* 42

Fig. 13. Human embryo of 1.54 mm. (von Spee). X 23. Dorsal view . . . . . *facing page* 44

Fig. 14. Human embryo of 4.2 mm., in lateral view (His). X 15 . . . . . *facing page* 44

Fig. 15. Developing brain from a human embryo of 7 mm. *facing page* 46

Fig. 16. The pallium and cerebellum in the brains of various vertebrates . . . . . *facing page* 48

Fig. 17. The individual and evolutionary development of the nerve cell 49
Fig. 18. Section through the spinal cord showing the early development of a spinal nerve . . . . *facing page* 50
Fig. 19. Organs developing from the rudimentary alimentary canal 52
Fig. 20. The development of the human heart 54
Fig. 21. The development of the face of a human embryo (His) *facing page* 56
Fig. 22. The relation of the fetal to the maternal blood in the human placenta . . . . . *facing page* 58
Fig. 23. Comparison of the embryos of various mammals at corresponding stages of development . *facing page* 62
Fig. 24. Changes in proportion during growth 66
Fig. 25. Growth curves for increase in weight and stature in both sexes 68
Fig. 26. The cæcum and vermiform appendix in various mammals 74
Fig. 27. Supernumerary nipples of man 77

PREFACE

The contents of this book have as their basis a series of lectures bearing the same title which were given at Yale University, during the academic year 1921-1922, under the auspices of the Society of the Sigma Xi. As President of the Yale Chapter for that year it became my duty to arrange the program for the Society, and after considerable thought I came to the conclusion that the previous successful series of Sigma Xi lectures, which were given in 1916-1917, and later published by the Yale University Press, on "The Evolution of the Earth and Its Inhabitants," could be continued with interest and profit by another series in which specific consideration was given to the question of the evolution of man. Accordingly a series of lectures was arranged as follows:

THE EVOLUTION OF MAN

Lecture I. The Antiquity of Man, December 2, 1921, *Professor Richard Swann Lull.*

Lecture II. The Natural History of Man, January 20, 1922, *Professor Harry Burr Ferris.*

Lecture III. The Evolution of the Nervous System of Man, February 10, 1922, *Professor George Howard Parker.*

Lecture IV. The Evolution of Intelligence, April 11, 1922, *President James Rowland Angell.*

Lecture V. Societal Evolution, March 10, 1922, *Professor Albert Galloway Keller.*

Lecture VI. The Trend of Evolution, March 22, 1922, *Professor Edwin Grant Conklin.*

The first lecture, by Professor Lull, sets forth the paleontological evidence for the evolution of man. In the second, Professor Ferris gives in detail, largely from the anatomical and embryological standpoints, some of the important

evidence for evolution which is to be found in the development and structure of present-day man. The third and fourth lectures, by Professor Parker and President Angell respectively, constitute a unit in which the evolution of the highly specialized and preëminent nervous system of man together with the development of intelligence are given consideration. Professor Keller, in the fifth chapter, presents the question of evolution in the various institutions of human society, and, finally, Professor Conklin sets forth his views with regard to the trend, or future, of evolution. The large attendance at each of the lectures is sufficient evidence of the extreme interest in the question of the evolution of man, and it is hoped that the publication of this book will stimulate an even greater interest in this very important subject. It is believed that the main scientific facts which bear upon the question are here presented from a modern viewpoint in an interesting as well as authoritative manner.

In conclusion, as President of the Society and editor of this volume, I desire to express my deep gratitude to the authors for their willingness to take the time and energy to prepare the lectures and to arrange their manuscripts for publication; to the officers, committees, and members of the Yale Chapter of Sigma Xi who by their enthusiastic coöperation made it possible to carry through the year's program successfully; to my colleagues in the Department of Zoölogy and elsewhere in the University, who have shown their active interest in the project in many ways, and, finally, to the Yale University Press for the splendid attitude they have shown in all matters connected with the publication of this volume.

GEORGE A. BAITSELL,
President, Yale Chapter, Sigma Xi.
1921-1922.

Osborn Zoölogical Laboratory,
Yale University, July, 1922.

FIG. 1A. SKULL OF NEANDERTAL MAN
From La Chapelle-aux-Saints. Restored by McGregor.
R, portion restored.

FIG. 1B. SKULL OF CRÔ-MAGNON MAN
From Grotte des Enfants. After Verneau.

Reproduced by courtesy of Doctors J. H. McGregor and W. K. Gregory,
of the American Museum of Natural History.

CHAPTER I

THE ANTIQUITY OF MAN

RICHARD SWANN LULL
PROFESSOR OF VERTEBRATE PALEONTOLOGY, YALE UNIVERSITY

THE Mosaic account of the creation, which has been and is yet of wide acceptance, would give us a very recent date for man's advent on this planet. The strictest interpretation of this account is that of Doctor John Lightfoot, a profound Biblical scholar, vice-chancellor of Cambridge University in 1654, who is often quoted because of the exactness of his findings. As a result of careful searching of the Scripture, Doctor Lightfoot was led to declare that "Heaven and earth, centre and circumference were made in the same instance of time, and clouds full of water, and man was created by the Trinity on the 26th of October 4004 B. C. at 9 o'clock in the morning."

One questions, however, not the Scriptural account but the exactness of its interpretation. The researches of oriental scholars are bringing more and more into evidence the historical truth of the Old Testament narratives, and are establishing from other lines of evidence the historical character of Abraham, Isaac, Jacob, and the other Hebrew patriarchs, but they are also tracing back into a more and more remote period the history of the Near Eastern peoples, as the result of the extensive excavations, with their treasure trove, which are being carried forward in these venerable abiding places of mankind.

Among the most interesting of these finds has been the bringing to light of several tablets, one of which is preserved in the Yale Babylonian Collection, and which constitute the oldest human documents thus far discovered. These several tablets are of black stone, of no very great size, but bear engraven on their surfaces characters which give to us a message out of the past, the time of which antedates that of Christ by some 5,500 to 6,000 years; in other words, a thousand or more years before Doctor Lightfoot's date. Nor is this all, for the inscriptions are no longer in the so-called picture writing or ideographs, but in a form of writing undoubtedly derived from this. They have progressed so far along an evolutionary pathway that the original pictures cannot in some instances be even guessed at. This, it would seem, implies a centuries-long developmental period before the beginning of inscriptive writings, and the inference is also justifiable that the protoscript could not have been invented but by peoples of considerable intellectual powers who had long since emerged from savagery and were vastly further yet removed from their ultimate beginnings.

The third line of evidence is cultural, based not on inscriptions or documents of any sort, but upon the implements and weapons of vanished peoples, with their varying degrees of refinement. Historic times, as is well known, are often spoken of as the Age of Iron, and perhaps the Age of Bronze, while the prehistoric is called the Age of Stone. But the Stone Age again has its subdivisions into, first, the New Stone Age or Neolithic period, in which the distinctive characteristic of the implements is that some of them at least were rubbed smooth or polished after the preliminary fashioning was completed. Back of this period lies the Paleolithic, varying immensely in the degree of perfection of use and workmanship, so that archeologists are agreed upon a number of cultures (see table, *infra*), based upon distinctions some of which are evident

to the most casual observer, while others are discernible largely to the expert only. Back of the Paleolithic lies the Eolithic, or Dawn Stone implement period, the definition of which originally implied that the stone implements of that time were not artifacts in the sense of purposeful manufacture, but that they were merely pieces of stone of convenient size which showed the effect of use. Later authorities admit of the presence of certain retouching on the margins of implements they still call eoliths, although just where they would draw the line between eoliths on the one hand and paleoliths of crudest workmanship on the other is not clear. Yet other authority would disclaim any human association with these eoliths, either of use or manufacture, and invoke the physical forces of nature to account for their seeming. But our purpose is not to tell again the arguments, but merely to establish, if possible, on the basis of such evidence, a further criterion for the testing of man's antiquity. It becomes at once evident, however, that all races of mankind are by no means in the same degree of cultural advancement at a given time, and that for ages of human history the relatively static and the highly advanced peoples must have dwelt contemporaneously in divers portions of the earth, just as, for instance, the native Tasmanians, of whom the last survivor died in 1877, were in a state of culture which some have called Eolithic and others a rather early stage of the Paleolithic, perhaps Mousterian (Osborn). It becomes necessary therefore to confine ourselves to some definite region which has been the home of mankind from remote ages, in order to establish a chronological series. There is no doubt in my mind that in the course of time certain portions of Asia will provide us with a chronology of great interest and amazing antiquity, but thus far our knowledge of European cultures is at once the most detailed and the most accurately dated, and the one with the fewest omissions in the series. There are readily applied checks on the European chronology, for it has

been synchronized very accurately with the successive advances and retreats of the ice in the Pleistocene glacial epoch, as well as with the recorded changes in the faunæ of these several stages. Hence the European cultural chronology has become the standard for the world, and as it is further possible to synchronize the periods of glaciation in the Old World and in the New, a comparative chronology for the latter may some day be established.

The appended table is based upon the highest authority, the American Osborn and the Belgian Rutot. Osborn feels convinced that Pliocene man is established by the Foxhall flints (see page 36), which he says are not Eolithic but Paleo-

CHRONOLOGICAL TABLE

CHRONOLOGY		INDUSTRIES	RACES OF MAN
	Postglacial time	Magdalenian, Aurignacian } Upper Paleolithic	Crô-Magnon, Grimaldi, ?Rhodesian
Quaternary (Pleistocene)	4th Glacial time	Mousterian } Lower Paleolithic	Neandertal
	3d Interglacial time	Acheulian } Lower Paleolithic	
	3d Glacial time	Chellean	
	2d Interglacial time	Chellean	?Piltdown
	2d Glacial time		
	1st Interglacial time		Heidelberg
	1st Glacial time	Cromerian	
Tertiary	Upper Pliocene	Foxhallian-Red Crag, Pre-Crag	*?Pithecanthropus*

lithic in that they show the mark of fabrication; and to the Foxhall beds is assigned a conservative age estimate of more than half a million years.

But Europe is not supposed to have been the original evolutionary center of mankind; its small size seems to preclude that. Rather is it a place to which, as in historic times, migrating hordes came from time to time when force of circumstances drove them out of Asia and perhaps more rarely from Africa. That Asia is the birthplace of mankind is seemingly established, the following being some of the evidences for this belief.

Asia possesses great size, and hence varying life conditions, together with a central location contiguous to all other land masses, even, as the north polar projection shows (Fig. 2), to North America. From Asia, as from no other of the continents of the world, is communication so easy and the migratory routes so clearly discernible. Asia is the home of the highest and best of the higher organic life and is with few exceptions the place whence man has derived his dependents and allies, the domestic animals and plants. Asia is the seat of the oldest civilizations, many indications of which, though visible as sand-drifted ruins, have outlived the vaguest traditions concerning their origins. Finally, the physical and climatic conditions of Asia in the Tertiary era were such as the scientist must postulate in his imaginings of the *modus operandi* of human origin from his prehuman forebears, i.e., such as would enforce descent from the trees and terrestrial adaptation.[1] The fact that the most primitive peoples to-day—African pygmies and Australian blackfellows—are not Asiatic does not tend to controvert but rather to strengthen this belief,

[1] See Lull, in "Evolution of the earth and its inhabitants," Yale University Press, 1918, pp. 142-143; and Joseph Barrell, "Probable relations of climatic change to the origin of the Tertiary ape-man," Scientific Monthly, January, 1917, pp. 16-26.

FIG. 2. MAP TO ILLUSTRATE THE BROADER LINES OF DISPERSAL OF THE PRINCIPAL RACES OF MAN

Modified from Matthew.

for as the first formed ripples of the widening circle caused by a stone dropped into a pool are the outermost, so the descendants of the earliest migrants should to-day be found farthest from the center of origin. The fact that the most ancient human remains in point of time thus far discovered are Javanese and therefore nearer the focal point is yet another bit of evidence.

It is with great confidence, therefore, that one looks to Asia, which is now for the first time being systematically explored by the American Museum of Natural History, to solve by actual findings this age-old problem of human origin.

Fossil Man

Our final and, to the paleontologist, most convincing line of evidence for man's antiquity lies in the discovery of actual remains of human beings which a fortunate combination of circumstances of burial, conservation, and subsequent discovery has brought before us. That these are rare is self-evident, for even under the most favorable conditions for fossilization, those of shallow-water marine deposits, it has been estimated that but 1,044 out of each 100,000 different forms that lived are known to us. Can we expect, therefore, that the record of what were evidently largely forest-dwelling creatures whose remains are but rarely preserved and who in this instance undoubtedly had methods of disposing of the dead by burning, possibly by consumption as an article of diet, or by merely casting out to be devoured by beasts and birds of prey, could possibly be as perfect as that of the marine forms? One marvels, not that the missing links in our chain of evidence are many, but rather that we possess any chain at all.

Conditions of preservation. There are but two conditions under which the remains of man are ever found: one, the older and rarer, in the valley sediments of rivers which deposit and scour away and deposit again in time of flood or of tran-

quil flowing, and occasionally catch and drown the unwary, as they do to-day, to bury their remains under tons of sediments which are subsequently removed and their contents exposed either by natural or by human agencies. The other more fruitful source is the underground caverns of Europe—abandoned subterranean river beds which are always to be found in limestone countries and which, when opened to the air through the eroding away of overlying materials by rain, frost, and snow, formed an inviting retreat from inclement weather and the assaults of savage beasts. These caverns thus became the place of abode and often of sepulture of prehistoric man, but were evidently not available for his tenancy until comparatively late in time (Mousterian, see table, page 4).

Means of determining antiquity. The criteria for establishing the antiquity of human remains are three. First, the geological age of the strata wherein the remains lie; secondly, the associated animals or artifacts or both; and third, actual somatological distinctions from existing man. The first must be most carefully weighed, and in general such is the very natural scepticism even among scientists that it is well to have corroborative evidence by unimpeachable witnesses both of the discovery and the exhumation. It is further necessary very carefully to distinguish between natural deposition of remains and intrusive burial, such as is often practiced by mankind, which places the subject among objects which may far antedate it in time. A scattered skeleton and one overlaid by absolutely undisturbed deposits are both good criteria of contemporaneity, but chance often makes strange bedfellows. Thus the finding by the writer of a glass bottle, bearing all the marks of extremely recent manufacture, *beneath* the hip bone of an extinct horse in an apparently undisturbed Pleistocene deposit in Texas was a little disconcerting until the looseness of the surrounding sand betrayed a filled-in animal burrow into which the bottle had undoubtedly been thrust. The asso-

ciation therefore with extinct animals and even an apparently like degree of fossilization are not entirely trustworthy when taken alone. Associated artifacts when implying ceremonial burial are fairly safe criteria and have been given high value in European age determination.

The final criterion, that of anatomical distinction, is of course highly valuable, but has led to difficulties, as, for instance, when a modern type, such as all the American ones prove to be, shows other indications of great antiquity. It was formerly supposed that there was but a single line of phyletic descent to modern man, but the belief is gaining ground that, as in the evolution of horses, the story is not so simple as was at first supposed, but that there were several lines of descent all of which may be of ancient origin, so that what have been called modern types of mankind might well be found contemporaneous with, or even antecedent to, the remains of more primitive races. This will be discussed in greater detail below (page 35).

Record of Discovery

New World. A brief *résumé* of the discoveries of the actual osseous remains of prehistoric man which have thus far come to light emphasizes the antiquity of his world-wide distribution, but we are not yet in position to date with finality the earlier men of the New World. Of these, North America has produced a number of specimens, the oldest of which in time of discovery is the so-called Calaveras skull, found, together with certain implements, stone mortars and pestles, spearheads and hammer stones, embedded in Californian gold-bearing gravels of undoubted Pliocene age. How this material came there is a mystery, but at present the Calaveras man is not supposed to have been contemporaneous with the gravels but to represent a man both physically and culturally of much later date.

Again and again such specimens have come to light, as in the Trenton gravels which date from the final retreat of the ice, the Nebraska loess man near Omaha, the Lansing man, and that of Vero, Florida, where the remains of like degree of fossilization with their animal associates were found entombed with creatures of undoubted Pleistocene affinities. Still other finds are those at Rancho La Brea in the Pleistocene asphalt of California, and lastly at Dallas, Texas, in the Lagow sand pit, associated with a Pleistocene fauna recently described by the writer. Not one of these, despite their fulfilment of every other prerequisite to antiquity—burial in older strata, animal association, like degree of fossilization, and so forth—meets the requirements of the physical anthropologist, for none shows somatological characters which are not possessed by the modern American Indians. This leads Doctor Hrdlička to doubt their antiquity, but a growing conviction in the author's mind, stimulated by so high an authority as Sir Arthur Keith, of the Royal College of Surgeons, London, is that, on the other hand, they may in part be of genuine Pleistocene age and hence point to the high antiquity of the Indian type.

The South American record is comparable. Florentino Ameghino (1912) described supposedly human forms under the names of *Tetraprothomo* and *Diprothomo,* based upon remains which in at least one instance owed their peculiarity to the fact that they were not even human. But in no event were these so-called men as old or as primitive structurally as Ameghino would have us believe, and his thesis that South America may have been the radiation center of the human stock seems untenable.

If none of the New World men are of archaic cast, their association with extinct forms, as for instance with the mastodon in the north and with living ground sloths in the south, seems to bear the mark of authenticity. The most authentic

northern instance is that described by Doctor J. M. Clarke, of the association in Attica, New York, of mastodon remains with charcoal and pottery. Four feet below the surface, in a black muck, Clarke found the bones of the mastodon, and twelve inches below this, in undisturbed clay, pieces of pottery and thirty pieces of charcoal. The association of the mastodon with the charcoal is not so significant, as it is conceivable that charcoal may have been formed by natural means, but not the pottery. The issue of the magazine *Natural History* for November-December, 1921, figures what seems to be the crude outline of a mastodon on a piece of bone from Jacob's cavern, Pineville, Missouri, in a way comparable to the Upper Paleolithic engravings of Europe.

In South America, again, the association of man and the ground sloth, *Grypotherium,* in a cavern at Lost Hope Inlet, Patagonia, seems definitely established. The fresh-looking remains, shreds of skin which show indications of having been cut with primitive knives, the presence of apparently cut grass, all point to the cherishing by man of what were probably the last of these creatures, either in the rôle of domestic animals or of those sacred to some deity as was the Egyptian bull Apis.

Keith is greatly impressed with the diversity of American languages and the high development of pre-Columbian civilizations in the New World, and feels that they point to an antiquity far beyond that commonly accepted by the ethnologist. On the other hand, all indigenous New World men are of essentially the same general racial type, the Mongoloid, nor have they been here long enough to establish racial differentiation comparable to that of the Old World.

Old World. Africa has been productive of but two osseous specimens of man of marked antiquity. One, found at Oldoway ravine, Tanganyika Territory, in the early days of the Great War, is impressive neither for its apparent age nor

its somatological peculiarities. The latest find, however, from Broken Hill mine in northern Rhodesia, has aroused a great deal of interest, because, while not very decisively dated and associated with a recent fauna all of which are either now alive or were so at the coming of white men, the skull itself is of a most peculiar and interesting type, clearly not that of modern man. And the finding of a second specimen which, while fragmentary, serves nevertheless to show community of type with the first, seems to establish the remains as representatives of a race and not due to individual peculiarities.

Arguments such as those recently offered by Churchward[2] striving to prove the ancestral character of the African Bushmen and the fact that Africa may be the primal home of mankind are not yet established theses. Northern Africa in the Barbary States has produced cavern murals comparable to those in southern Europe, and Sollas has made much of Bushman affinities in all of these artistic remains, but these are late in time (Upper Paleolithic, Magdalenian) and do not aid us in our establishment of high antiquity for African man. Undoubtedly Africa is an old, old home of mankind—all signs point to that conclusion—but the actual skeletal remains of types anterior to our own species are, as we have shown, but a single find. This is undoubtedly due largely to paucity of discovery rather than to lack of occurrence.

Of Asia, a similar tale is told, *Pithecanthropus,* found in 1891 in Trinil, Java, being still unique, although one looks daily for the announcement of further finds as the outcome of the American Museum's Asiatic expedition now in the field. Again, we simply do not know the country paleontologically.

At Darling Downs, Australia, a human skull has been found, apparently in association with extinct Pleistocene Mammalia.

The European finds, on the other hand, are relatively so

[2] A. Churchward, "The origin and evolution of the human race," New York and London (Macmillan), 1922.

numerous that as we have established our cultural chronology upon European discovery, so we must base our conception of human antiquity and evolutionary lines largely upon European material. For Europe is small, accessible, and the home of an enthusiastic band of workers whose efforts have been untiring and whose results are already at hand, although much will come to light in the future.

Prehistoric Human Species

Pithecanthropus erectus

Taken in order of chronological sequence, the Asiatic *Pithecanthropus* stands first, as it does in most respects in the characteristics which it betrays. Found in 1891 in the deposits of the Solo River, near Trinil, on the island of Java, these fragments of humanity are most meager, but such as they are, they throw a flood of light on human origins. It is to be regretted, however, that their custodian, Doctor Dubois, a Dutch army surgeon, now professor of physical geography in the University of Amsterdam, will not permit their further study by his colleagues. Our knowledge therefore is based on Dubois's own admirable researches, together with the widespread replicas of the *external* aspect of the calvarium, which have enabled some independent conclusions to be drawn. The remains include the skull-cap, three teeth (M^2 left, M^3 right, P_2 left), and a left femur, the last bearing an exostosis indicative of injury or disease. These probably pertain to a single individual, although they were found scattered through some twenty yards of space and were not all discovered at the same time. This scattering precludes the possibility of intrusive burial, however. The most careful search has failed to reveal any further fragments except a fourth tooth, brought to light by a special expedition under the direction of Madame Selenka. So much has been written concerning this type of man that the

summary of conclusions, which, however, lack the finality of finished research, is all that need be given here.

The skull-cap is dolichocephalic, estimates of the cranial capacity varying from 710 to 1,060 c.c. as compared with 930 to 2,000 c.c. for modern man. The brain, while human in some respects, is subhuman in others, especially in that area in which the memories of past impressions derived from the higher senses are recorded. Whether or not speech was actually used is questioned, but the possibility of it seems clear.

The straightness of the thigh as compared with that of Neandertal man (see *infra,* page 24) is marked, so that in *Pithecanthropus* the posture must have been as fully erect as in modern man. In this he is in no sense a transitional form but in skull characters he is, for the shape of the thigh is correlated with that of other parts, the vertebral column with its curves, the pelvis, and the poise of the skull, all of which, one may infer, were distinctly human.

The teeth of the Java man are also of a distinctly human type, showing no shortening of the roots or development of the pulp cavity, to which Keith has applied the term "taurodont" (ox-tooth), as in the Heidelberg and Neandertal races to be described later. The alternative type of teeth he calls "cynodont" (dog-tooth), such as those of modern man and the apes, adapted to a more varied and less harsh diet. *Pithecanthropus* had teeth of the latter type. The tooth crowns are wider than long, the reverse of simian dimensions, and although they do show certain minor ape-like characters, they also show certain degenerative features.

Gregory (1920, page 690) thus sums up the status of *Pithecanthropus:*

> The association of gibbon-like skull-top, modernized human femur and subhuman upper molars with reduced posterior moiety, if correctly assigned to one animal, may perhaps

define *Pithecanthropus* as an early side branch of the Hominidæ, which had already been driven southward away from the primitive center of dispersal in Central Asia, by pressure of higher races. But whatever its more precise systematic and phylogenetic position, *Pithecanthropus,* or even its constituent parts, the skull-top, the femur and the molars, severally and collectively testify to the close relationship of the late Tertiary anthropoids with the Pleistocene Hominidæ.

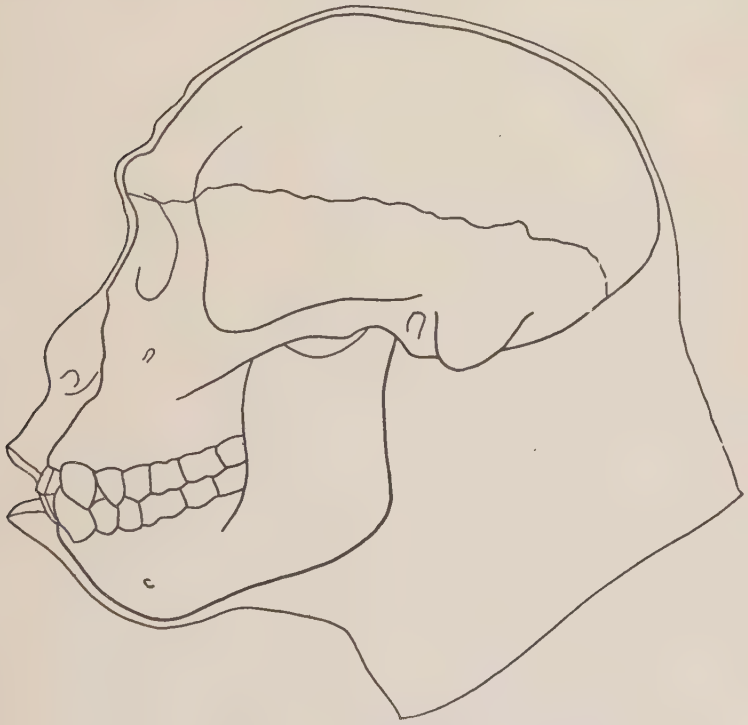

FIG. 3. SKULL AND FACE OF THE JAVA MAN
Pithecanthropus erectus.
Two fifths natural size. Portion below irregular line restored.
Adapted from McGregor.

Of restorations of *Pithecanthropus,* several have been attempted. The skull completion here shown (Fig. 3) is derived from the studies of Dubois and McGregor. The latter has

done an admirable bust based on the most careful detailed study (see Frontispiece).[3]

Pithecanthropus was found associated with twenty-four or more species of mammals, all of which are now extinct and whose affiliations are distinctly Pliocene. Gregory (1921, page 691, Fig. 270) shows this ancient relic as of upper Siwalik age (Pliocene). Dubois considered its assignment to late Pliocene and therefore equivalent to the Cromer forest beds of England (see *infra*). Keith describes its geologic occurrence as follows: under the fossiliferous bed is a stratum of conglomerate, then a layer of clay laid down in quiet muddy water, under the clay a marine deposit containing early Pliocene fossil shells corresponding to the "Crag" of East Anglia. Over the fossil beds containing *Pithecanthropus* are stratified deposits forty-five feet in thickness, recalling the Mauer sands (see page 17). In terms of years, a conservative estimate would give to *Pithecanthropus* an age of 400,000 to 500,000, or in round numbers approximately half a million years.

Heidelberg Man (*Homo* (*Paleanthropus*) *heidelbergensis*)

The jaw upon which this species is based bears the unique distinction of having caused no controversy whatever among anthropologists, for the absolute perfection of the specimen, the stratigraphic position, and the circumstances of its discovery leave no ground at all for doubt or dispute. It came to its fortunate discoverer, Doctor Otto Schoetensack, as the just reward of some twenty years of patient scrutiny and expectation. It was found at Mauer in southern Germany in 1907. This little village lies in the valley of the Elsenz, a tributary of the more famous Neckar, and at a distance of ten

[3] See Lull, "Organic evolution," Macmillan, 1917, Pl. XXX, Fig. A. McGregor's restorations, and those of Rutot, are reproduced in Osborn's "Men of the Old Stone Age." Rutot's are also to be found in "Prehistoric man and his story," by G. F. Scott Elliot, Seeley, Service & Co., 1915.

kilometers southeast from the city of Heidelberg, famed for being one of the oldest seats of scientific learning in central Europe. The Mauer sands are river valley deposits, the upper portion of which is regarded by Schoetensack as upper, the rest as lower, Pleistocene. From this locality has come a fauna of mammals which compares with that of the pre-Glacial forest beds of Norfolk, England. The jaw itself was found in the lower portion, about seventy-nine feet below the summit of the deposits.

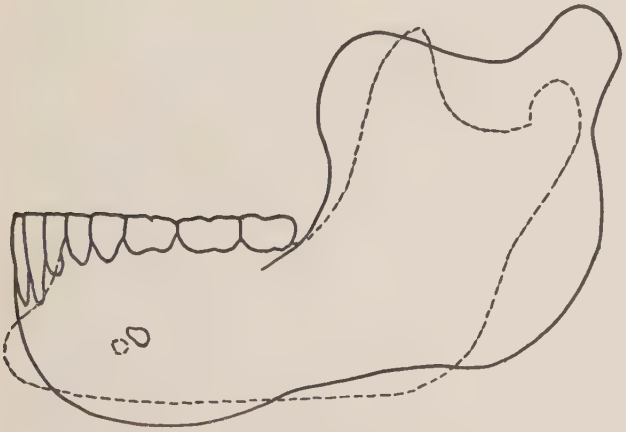

FIG. 4. HEIDELBERG MAN
Homo (Paleanthropus) heidelbergensis.
Mandible compared with that of a modern European (broken line).
Two thirds natural size. After Schoetensack.

The lower jaw is complete to the last detail, although the teeth of the left side, which adhered to a limestone pebble, were broken off upon the removal of the latter. They are, however, carefully preserved, and the accident brought to light yet other characteristics not otherwise visible.

The jaw is very primitive, heavy, and massive. It lacks entirely the chin prominence so characteristic of modern man, as the front profile of the jaw slopes away as does that of a

gorilla. Within the jaw at the symphysis there is the genial pit for the attachment of the tongue muscles as in the anthropoids, and, like them, the bone encroaches on the floor of the mouth. In both these respects the jaw is more simian than human but not sufficiently so to preclude the possibility of rudimentary speech. The body of the jaw is not unlike that of the successor of Heidelberg man, the Neandertal race, but the ascending branch which gave attachment for the masticating muscles differs in shape, being gibbon-like, and is much greater, as great in fact as that of a female orang. The teeth, while actually large, are relatively small, and the taurodontism is developed in a marked degree, as shown by the enlarged pulp cavity, dilated crowns, and abbreviated roots. The teeth are regularly placed and the canines are not in any way bestial in their development, less so, indeed, than in some modern men. Without the teeth, the Heidelberg jaw might well be considered as that of an ape, but the teeth affirm its human affinities although in their development and in the form of the dental arch they are prophetic of Neandertal, not of modern, man. Keith does not believe that either Heidelberg or Neanderthal man lies in the direct line of modern descent, but that the taurodont dentition implies a specialization for a rough herbivorous diet and that in this respect both races show a departure from the more simian dentition and implied feeding habits of the main line of descent into *Homo sapiens*.

While the skull of Heidelberg man is yet unknown, Doctor McGregor has nevertheless attempted its reconstruction, for of course many dimensions, as well as the character of the upper teeth, can be learned from the lower jaw, while the remainder of the skull was studied from its Neandertal successor. The result is a pre-Neandertal skull, elongated, with a low forehead, prominent brow-ridges, and a rounded dental arch, and there is reason to believe that this reconstruction will prove prophetic when the actual cranium is revealed to us by

discovery, unless the latter shows certain unique and entirely unexpected features.

The probable contemporaneity of the associated fauna with that of the pre-Glacial forest beds has already been mentioned. Osborn in 1915 considered both the fauna and the jaw to pertain to the Second Interglacial time, but Schoetensack, Geikie, and others would assign them to the First Interglacial (Lower Pleistocene). Gregory says (1921, page 126):

If of Lower Pleistocene age, the Heidelberg jaw shows that the most important diagnostic characters of the dentition of the Hominidæ had already been acquired at the beginning of the Pleistocene epoch and indicates that prehuman transitional conditions must be sought in earlier geological ages. If, on the other hand, the Heidelberg jaw dates only from the Middle Pleistocene, then transitional conditions may be looked for as late as the Lower Pleistocene or Upper Pliocene.

The age of this venerable relic read in terms of years is at least 400,000, and the associated flints are Eolithic in culture.

The Dawn Man of Piltdown (*Eoanthropus dawsoni*)

This is by far the most ancient *English* human relic thus far discovered, although there is some question as to the precise dating and, owing to the fragmentary character of the material when it came into scientific hands, it has aroused a great deal of controversy, in marked contrast with the unhesitating acceptance of the jaw of Heidelberg. The specimen was found at Piltdown, on the Ouse, Sussex, in a shallow stratum of gravel, less than four feet in thickness at the point of discovery. This gravel rests on a bed-rock of Mesozoic age, the Hastings beds. From the lowest six-inch layer of the Piltdown gravels, where everything is stained a deep brown, came the skull, together with certain crude (Eolithic) implements and the remains of several animals, long since extinct. This

pit has been worked for some time for road-mending flints and thither occasionally came Mr. Charles Dawson, a local lawyer and antiquarian, to secure the flint implements which from time to time came to light. One day a workman gave Mr. Dawson a fragment of the skull parietal. This started a long search, ultimately resulting in the finding of other characteristic portions of the cranium, a ramus of the jaw with several molars *in situ,* a canine tooth, and two nasal bones. These fragments, which represented what was at first an entire skull unwittingly shattered by a workman's pick, were submitted to Doctor Arthur Smith Woodward of the British Museum, who began the laborious process of reconstruction of a complete skull from the several isolated pieces. It is but natural that among the several workers who essayed the same task, Smith Woodward, Keith, and McGregor, there should be some difference of opinion, which is manifest principally in a little variation as to the estimate of skull capacity. But in the main there is agreement as to the general form. The cranium is extremely thick-walled, averaging four tenths of an inch, with a rather steep, though contracted and ape-like forehead, and one that lacks the prominent brow-ridges of Neandertal man. The skull was nicely balanced on the neck as in ourselves, implying an erect posture in further contrast to the men of Neandertal. The brain-cast was submitted to the high authority of Professor Elliot Smith, who pronounced it the "most primitive and most simian human brain thus far recorded."

The jaw has proved to be a veritable bone of contention. Everything pointed to community of origin with the cranium, except its remarkably primitive character. One American authority, G. S. Miller, Jr., who studied, not the original but a cast, came to the conclusion that the jaw and skull could not possibly pertain to the same individual or even the same genus, but that the former was that of a fossil chimpanzee, to which

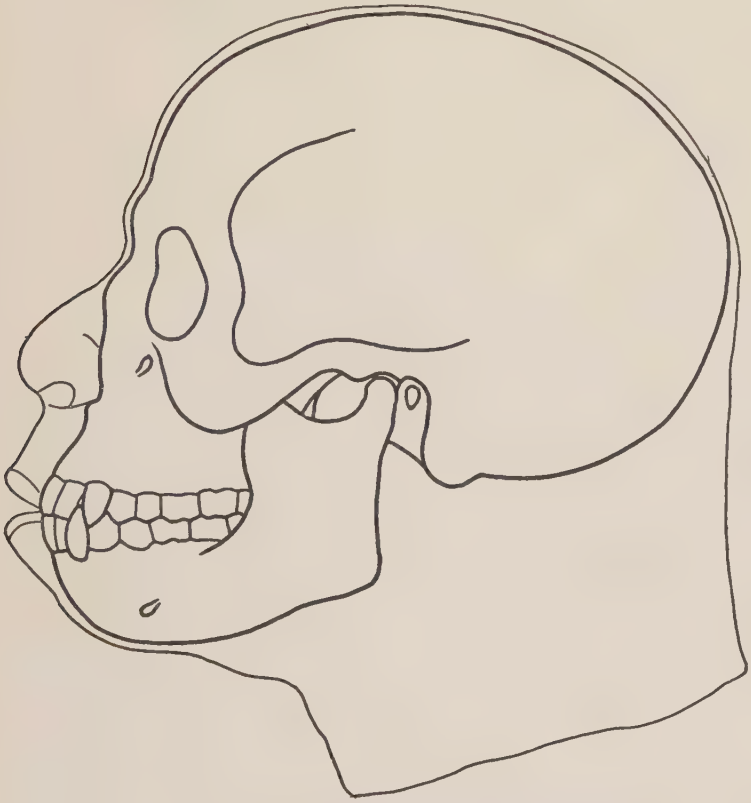

FIG. 5. SKULL AND FACE OF PILTDOWN MAN
Eoanthropus dawsoni.
Two fifths natural size. Adapted from McGregor.

the technical name of *Pan vetus* was given, despite the fact that fossil anthropoids were heretofore unknown in England. In this conclusion Mr. Miller has had quite a large American following. The matter has, however, been settled beyond question by the finding of a second specimen of the Piltdown man some two miles distant, consisting of diagnostic cranial fragments associated again with a lower molar of precisely similar character to those in the first jaw, a happening which could

hardly occur, according to the law of probabilities, in both of the only known instances if the jaw and skull were not those of the same form.

The jaw is indeed peculiar, as the symphysis is distinctly simian, while according to Keith, the rear part is as distinctly human. The whole, taken together with the canine tooth, points to a man of bestial visage, united with a rather modern-looking cranium, a combination which excludes him from our species and genus, and to which the name *Eoanthropus dawsoni* is most aptly applied, no one, as Keith says, having ever anticipated the discovery of one of man's progenitors showing such a remarkable mixture of human and simian characters. Chief among the peculiarities of the jaw is, therefore, the symphysis, which is even more simian than that of Heidelberg in that there is no rudiment or suggestion of the forming chin. The ape-like genial pit is present, together with the encroachment of bone on the floor of the mouth. The anterior teeth, so far as known, are also simian, while the molars are human, although, as Gregory says, extremely like those of a chimpanzee, but these, in turn, are closely related in pattern to primitive human molars.

As has been said, very primitive eoliths, stained brown, were found actually associated with the skull; in the gravel above, however, the flints are a brilliant colored iron red and of such degree of workmanship that Dawson considers them as Chellean or at the earliest pre-Chellean in age. The man, however, as has been said, was not buried down into the older strata but contemporaneous therewith, possibly the result of a drowning accident. The British authorities, Lewis Abbott and J. Reid Moir, both refer the older gravels to the Pliocene, but the more widely accepted belief is that the Piltdown man is Lower Pleistocene, of Second or Third Interglacial time, so that in terms of years his age is from 200,000 to 300,000 years.

These remains occurred so near the present land surface that had they not shown evidence of great structural antiquity, their authenticity would be greatly in doubt. As it is, they are conceded to be ancient, the chief discussion being as to how ancient and whether or not the jaw pertained, whether the canine tooth was upper or lower, and finally as to the cubic contents of the skull. (See Frontispiece and Fig. 5.)

Neandertal or Mousterian man (*Homo neandertalensis* or *primigenius*)

This is now a well-established race with considerable range of variation within it, for of it there have been found relatively numerous individuals of greater or less degree of perfection. Of these, the first in chronological order, and the most ancient in point of time, is the Gibraltar skull discovered in 1848, but unappreciated scientifically for so many years that its position in the series has been subordinate instead of at the head. It is now preserved in the Museum of the Royal College of Surgeons.

The most famous skeleton, which gave its name to the race, is that found at the mouth of a cave in the Neandertal gorge of the valley of the Düssel, a German tributary of the Rhine. While apparently nearly perfect at the time of discovery, but little of the skeleton is now preserved in the Provincial Museum at Bonn. A skull-cap, ribs, part of a right scapula, clavicle, humeri, ulnæ, femora, right radius, tibia, and a portion of the left pelvic bone are the chief parts remaining, and, as might well be supposed, the publication of the find gave rise to much contention as to whether it represented a type of man or was merely the relic of some poor waif of humanity, diseased or otherwise, the result of abnormal growth. It was not until the further discovery of two other individuals at Spy in Belgium in 1886, which again bore the

distinguishing features of Neandertal man, that it was fully conceded that they represented a race, and that the characteristics which they exhibited were diagnostic. Later finds, though not in chronological order, have been made at the following places:

Le Moustier, La Chapelle-aux-Saints, La Ferrassie, La Quina, and Pech de l'Azé, France; Banolas, Spain; La Naulette in the Lesse Valley, Belgium; Ehringsdorf near Weimar, Germany; Krapina, Austria.

The anatomical features of the Neandertal race are now very well known, largely through the very detailed studies of Professor Marcelin Boule on the material from La Chapelle-aux-Saints in the Paris Museum. *Homo neandertalensis* was of low stature, hardly exceeding five feet three inches for the males and less for the females. The posture was not fully erect,[4] as shown by the curved thigh bones, slighter cervical flexure of the spine, and the position of the foramen magnum of the skull. The head was borne on the immensely muscular neck in such a way that the face was thrust forward in an ape-like manner, thus lacking the delicate poise which it would possess were the carriage more fully erect.

The skeleton of Neandertal man is peculiar, not alone in the slight cervical flexure of the vertebral column and in the presence of curvature in the thigh, but in the enlarged articulation of the limbs, with knee and hip joints somewhat bent, and in the peculiarly rounded ribs, all of which point to a clumsy, shuffling, loose-jointed being of great muscular power. The distal segments of the limbs are relatively short, in marked contrast with those of the great man of Crô-Magnon described below.

The skull of Neandertal man is very large, with a cranial

[4] Careful studies of the specimens by Doctor McGregor, as yet unpublished, seem to indicate that the posture of Neandertal man was probably no less erect than that of some slouching modern types.

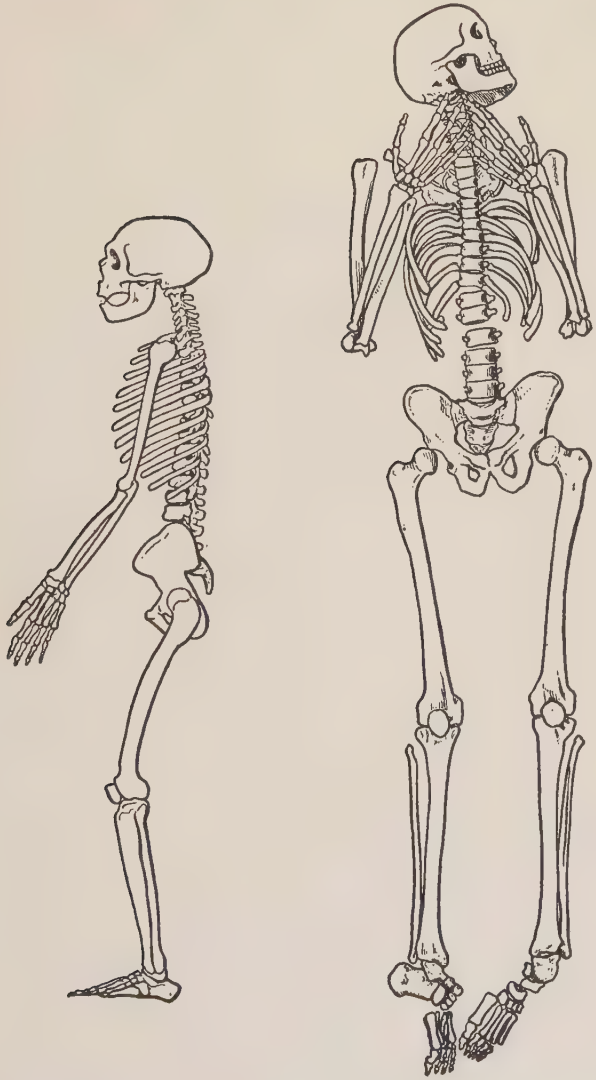

FIG. 6. SKELETON OF NEANDERTAL MAN (LEFT) COMPARED WITH THAT OF CRÔ-MAGNON MAN
From Lull, after Boule and Verneau.

capacity of 1,600 c.c. (La Chapelle) as against an average modern cubic content of about 1,400 c.c. The skull is long, as are all prehistoric crania, but the vault is low and the hinder part curiously depressed and broadened out, "bun-shaped," as Keith expresses it, which, together with the great apparent musculature of the neck, must have increased the peculiarity of his appearance. Anteriorly, the supra-orbital ridges or tori are greatly developed and are confluent across the forehead, not divided into two parts by a median depression as with modern man. The nasal profile is concave and the upper jaw very deep, indicating a long upper lip. The lower jaw is not unlike that of Heidelberg, nevertheless it shows a distinct advance over the latter in that, while the chin prominence is yet lacking, there is indication that dental reduction, already in evidence, is beginning to cause a recession of the tooth-line to a position more nearly above the chin, giving the latter a greater relief. (See Frontispiece, Fig. 1, and Fig. 7.)

The teeth are of the taurodont character defined above, large of pulp capacity and short of root, again an adaptation, according to Keith, to a coarse vegetative diet. In teeth and palate form, Neandertal man shows a greater degree of specialization than does our own race and this in a form in other respects more primitive.

The brain of this man was not as yet sufficiently advanced to learn to substitute other and more effective devices for various needs, so that the jaws still had varied uses in contrast with their very restricted function to-day.

The brain itself shows a certain specialization in its size, but the relative development of those parts wherein lay the higher mental functions was not great. Nevertheless, Neandertal man was a skilled worker in flints, had harnessed fire, and by the reverential burial of his dead surrounded by beautifully wrought objects whose surrender implied a very real

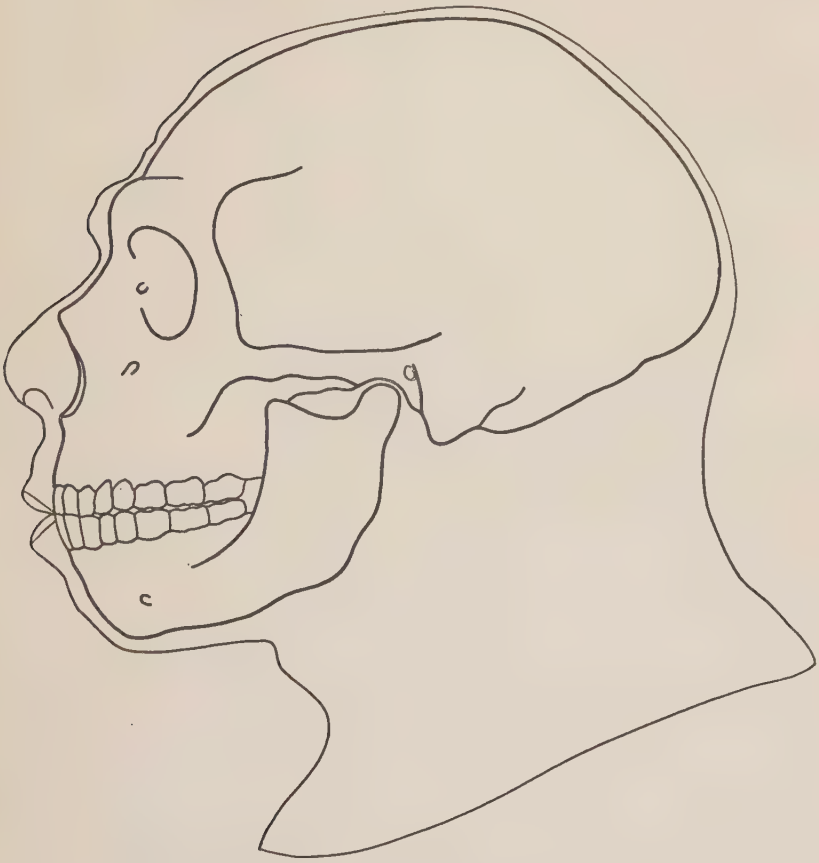

FIG. 7. SKULL AND FACE OF NEANDERTAL MAN
Homo (Paleanthropus) neandertalensis.
Two fifths natural size. Adapted from McGregor and Boule.

sacrifice on the part of the survivors, together with apparent food, had in greatest probability a belief of some sort in immortality.

It is in the form of the cranial cavity and of the supra-orbital ridges that the Neandertal skull departs most widely from that of modern man, and it is in these two points that the

resemblance with the anthropoids is most pronounced. They are both, however, in part at least, explicable as a response to great muscular development of neck and jaw. As Keith says of him, certain peculiarities of his were distinctly simian, but not all of them, as he possessed other traits distinctly his own.

The following ideas have been advanced concerning the status of this interesting race: that he was the product of disease; that he was ancestral to modern man, representing the Pleistocene stage in human evolution; that he was merely an extreme variant of modern man himself, who had retained an unusual share of ape-like traits. The present opinion, however, looks upon him as "a separate and peculiar species of man which died out during or soon after the Mousterian period" (Keith).

Modern representatives of Neandertal man. As a race, *Homo neandertalensis* is surely extinct. Whether or not his blood has entirely vanished from the earth is not known, for in diverse people, as, for instance, a certain Holland strain, the so-called Old Black breed of the Shetland Islands, and again in the west of Ireland, we find certain Neandertal characters still prevalent, but not all of them. The same thing is also true of the Australian natives, whose physiognomy is often very suggestive of the Neandertals, so much so that they have been held by certain authors to be persistent representatives of that race. But while many individuals show one or more of the distinctive characters, no one individual ever possesses all.

Rhodesian Man (*Homo rhodesiensis*)

The exact place of the interesting relic from Broken Hill mine, northern Rhodesia (see *supra,* page 12), is yet to be established, both from the standpoint of antiquity and the position that it holds in its human relationship. The preserved remains, probably complete when found by the workmen, con-

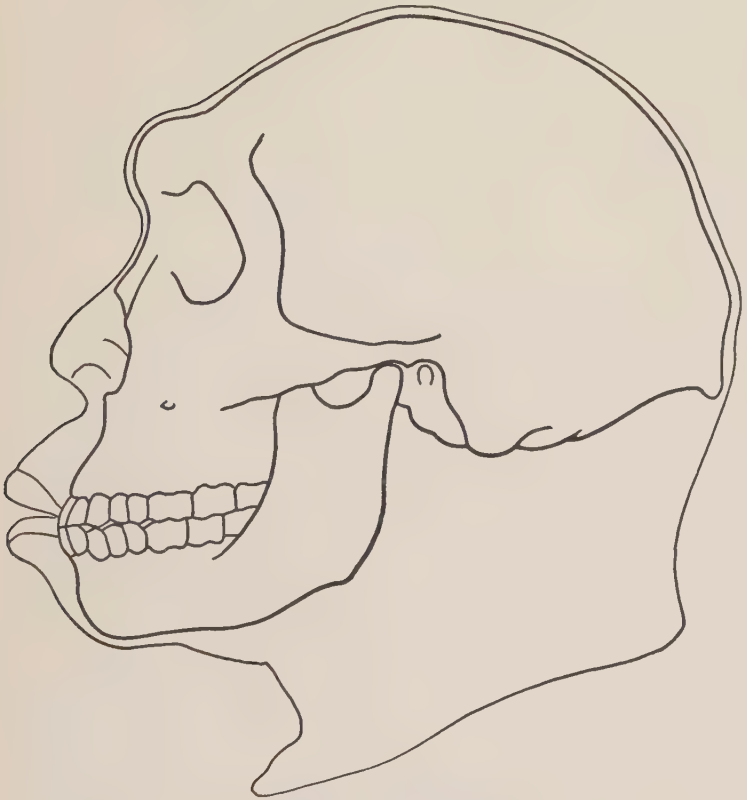

FIG. 8. SKULL AND FACE OF RHODESIAN MAN
Homo rhodesiensis.
Two fifths natural size. Adapted in part from Woodward.

sist of a skull with a part of the lower jaw, both so perfect that no questionable reconstruction of either cranium or facial bones need be made. Certain other skeletal elements are also present, such as the tibia and both ends of the femur, the collar bone, part of the scapula and of the pelvis. Part of the upper jaw of a second individual was found, thus establishing the existence of a race or tribe as against an aberrant individual.

The skull is not fossilized, except that its animal matter has been lost, and the associated animals are all recent, so that two of our criteria of age fail us in attempting to fix other than late Pleistocene or even the Recent period for the time when this man lived. The position of the remains in a cavern is not so trustworthy as usual, for while buried under tons of mineralized bones, they may well have been intruded by means of a shaft-like cave.

The cranium itself is not remarkable, either for its form or estimated content, which, as Keith tells us, falls between a modern English and an ancient French (La Chapelle) skull. This is as yet an estimate, as the matrix had not been removed from the interior of the skull at the time of the latest published description. We are therefore at present ignorant of any especial features which a brain-cast may reveal. Judging from the position of the foramen magnum, the head was well balanced on the neck, and this, together with the straight shin and the character of the ends of the thigh bone, imply a fully erect posture in no sense Neandertaloid.

The facial region, however, departs radically from what we have seen in that it shows a very primitive character in contrast with the more advanced cranium. The brows are immensely prominent, so much so that they dwarf the forehead above and give it a flattened look that closer scrutiny does not bear out. The nose was broad and flattened but human, and the palate so broad and rounded that it is less ape-like than in the modern negro. The lower jaw must have been of enormous strength and size to offset it. Smith Woodward tried the Heidelberg jaw on the skull but found it too short and narrow. The Piltdown jaw, on the other hand, he found too long, and to be further excluded from comparison by the prominent canines which in the Rhodesian man are not distinctively developed. The teeth as a whole are strongly rooted, although badly worn, and subjected to caries, a disease

never before observed in a prehistoric skull and almost unknown among Englishmen before the Roman invasion. The third molar or wisdom tooth is undergoing reduction as in modern man.

As one views the Rhodesian skull, he is certainly strongly impressed with its Neandertal-like appearance, but this, as has been emphasized, applies to the face, for the laterally compressed instead of depressed cranium, together with the implied erect posture, are departures in the more modern direction. It would seem therefore as though no close relationship is indicated between the two and that in most respects Rhodesian man is much more advanced. Certain community of food adaptation or use of the jaw instead of other means in accomplishing necessary work, may account for the facial similarities which in the Rhodesian man, as in that of Piltdown, may well have lagged behind the evolution of the rest of the skull.

Culturally, Rhodesian man must have been very primitive, for the only associated implements are certain rounded pieces of limestone of doubtful utility, although the crushed skull of a lion-like creature found in association is indicative of a certain defensive value.

Homo sapiens

Upper Paleolithic man. The most notable of the several races of our own species found in prehistoric Europe is that of Crô-Magnon, in almost all respects the most perfect man physically that has come within our knowledge. The first record of the existence of this race was found at Gower, Wales, where seventeen skeletons were discovered in 1852. These, however, were lost to science through subsequent burial in the village cemetery. Four years later others were discovered at Crô-Magnon, France, and these may yet be seen in the great Museum of the Jardin des Plantes in Paris. In all there were

five skeletons, an old man, a woman, a child, and two young men, and these specimens are now looked upon as the types of the race.

The most impressive thing about Crô-Magnon man is the majestic height, which averages six feet one and five tenths inches in the young men, while the old man was six feet four and five tenths inches. The women, on the other hand, had an average height of only five feet five inches, but little above that of to-day. The limb proportions and the great chest are suggestive of negroes, but not the skull, which is decidedly more Asiatic than African in implied affinities.

The skull is very large, even the female brain exceeding that of the average male of to-day. This is perhaps the more significant, since, as Keith says, the size of the body has a direct influence on the size of the brain. The Crô-Magnon skull, while long and narrow, is entirely modern, lacking as it does the great brow-ridges of his predecessors. Nor is the brain in any way distinctive from that of existing man. The face, on the other hand, is broad, especially across the cheek bones, giving a disharmony of face and cranium. The facial angle is equal to that of the highest modern man. (See Frontispiece, Fig. 1, and Fig. 9.)

The jaw is strong and the chin, though prominent, is narrow when seen from in front. The palate is also narrow and the dental arch and teeth are of a relatively high type.

In Obercassel, near Bonn, Germany, there is an extinct race resembling very closely the Crô-Magnons except for a short stature.

Culturally, these late Paleolithic men stood very high, not only in their production of flint implements of Aurignacian type (see table, page 4), but because it was in representatives of this race that primitive art found so high and so very remarkable an expression. This art—sculpture, engraving, and painting—has been found in great abundance in and upon

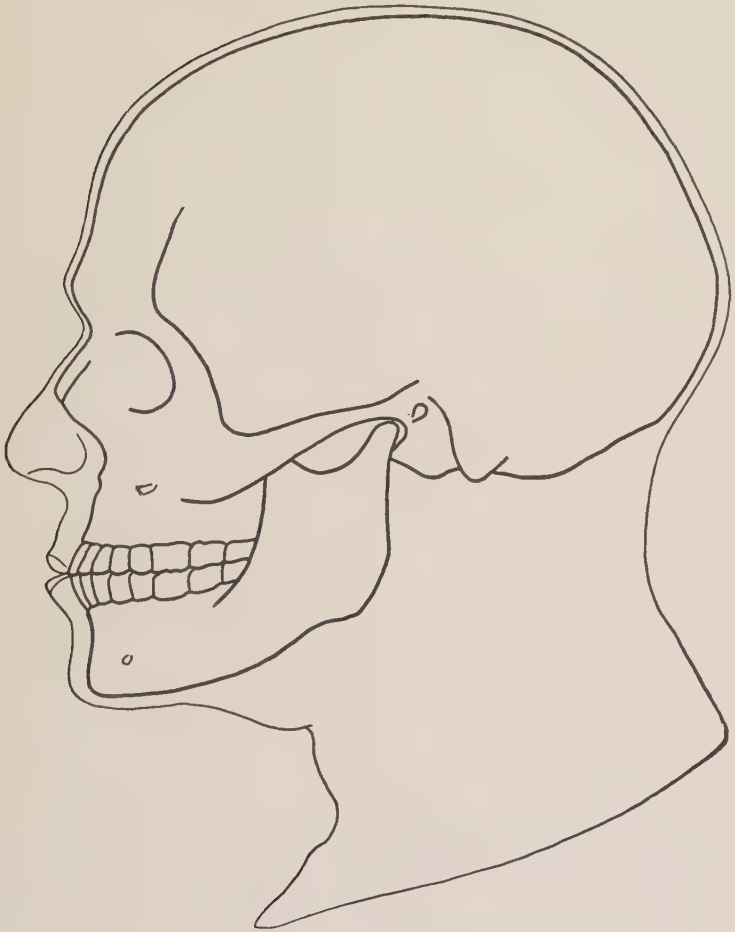

FIG. 9. SKULL AND FACE OF CRÔ-MAGNON MAN
Homo sapiens.
Two fifths natural size. Adapted in part from McGregor.

the walls of caverns in the Dordogne region and in the Bas Pyrenees, and on the northern coast of Spain. A detailed description of it is beyond the scope of this essay, and the reader is referred to the elaborately illustrated works by

l'Abbé Breuil,[5] Osborn and others. The significance of this work, whether religious or merely a manifestation of an artistic impulse, is not at all clear. That the great bulk of the representations were of animals has perhaps some bearing on the question; at all events, they give us an insight into the psychic development of a race 25,000 years ago fully in accord with their magnificent physique.

Among other types of *Homo sapiens,* more or less contemporaneous with Crô-Magnon man, is that of Grimaldi, of which the typical skeletons come from the famous Grotte des Enfants near Mentone in southern France. The individuals, a woman and a boy, were apparently laid on the floor of the cavern and protected by stone blocks over which in the subsequently accumulated cave earth there was buried a typical Crô-Magnon man. The Grimaldi individuals show several features which have been interpreted as negroid,—long narrow crania, flattened nose with typical nasal gutters at the base, protruding teeth and slightly retreating chin, and palate and teeth like those of the Australians. Although the lower limbs are disproportionately long, the stature was low.

Sollas makes much of this occurrence, together with the finding of steatopygous figurines in adjacent Mentone caverns suggestive in their conformation of characteristic bodily curvatures of the modern Bushmen. He therefore, on these and other data, concludes that "Mentone was inhabited at the beginning of the Aurignacian age by a race allied to the Bushmen." One is very loath, however much the resemblances may point to it, to attribute the glories of Aurignacian art to a negroid race, in the presence of the splendid Crô-Magnons. The Grimaldi men may have been representatives of a wave of invasion from northern Africa which spread for a while into Europe, to retreat once more before the advance of the

[5] References to the works of Breuil may be found in the bibliography of Osborn's "Men of the Old Stone Age."

more vigorous Asiatics. The Crô-Magnon race has also ceased to exist as such, although in the Dordogne region, within the limits of their ancient home, there dwell individuals which possess many of the physical traits of their probable Aurignacian ancestors. We have to go to Asia to the region north and south of the Himalayas to find peoples whose facial characteristics best resemble those of Crô-Magnon man, while the stature and bodily build are best displayed in the Sikhs.

The decline of the Crô-Magnons, Osborn says (1916, page 450),

> may have been due partly to environmental causes and the abandonment of their vigorous nomadic mode of life, or it may be that they had reached the end of a long cycle of psychic development. . . . We know as a parallel that in the history of many civilized races a period of great artistic and industrial development may be followed by a period of stagnation and decline without any apparent environmental causes.

There are yet a number of remains pertaining apparently to *Homo sapiens*. These are the Galley Hill skull in the Thames gravels, and the remains from Dartford, Clichy, Moulin Quignon, Grenelle, Denise, Olmo, and Castenedolo. All of these have been in dispute as to their antiquity, principally because of their very modern character. But Keith groups them collectively under the head of pre-Mousterian man, accepting Galley Hill, Clichy, and Olmo as certainties, and believes that they may well be cited to prove the great antiquity of our own species. Other competent authorities, however, consider the above cited as "impossible and not proven." Keith's contention is that *Homo sapiens* appeared at a remote time, flourished for a while, and disappeared, to be replaced by the more primitive but not ancestral Neandertal man of Mousterian time. This last was in turn deposed from human dominance and replaced by the higher race again in the character of Crô-Magnon man. He feels, therefore, that the

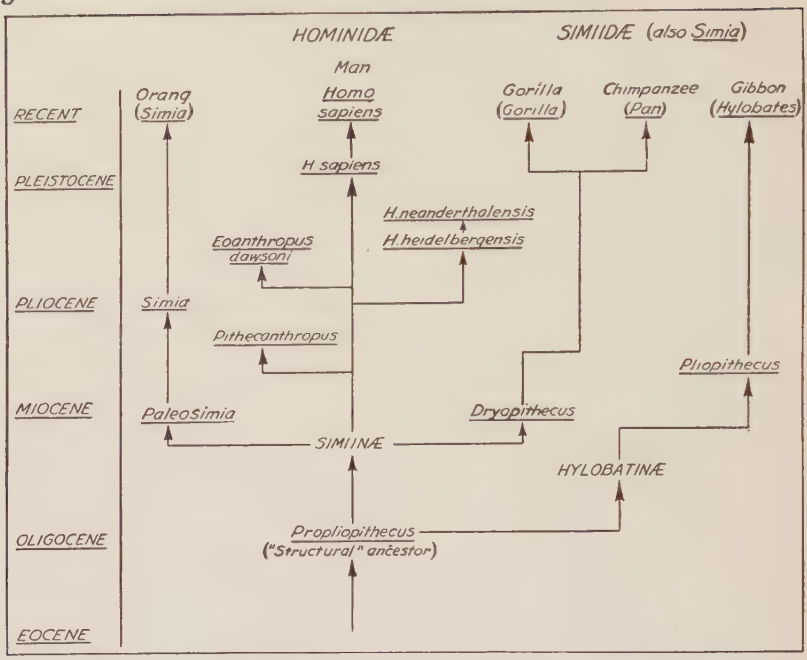

FIG. 10. PROVISIONAL PHYLOGENY OF MAN AND THE ANTHROPOIDS
Modified from W. K. Gregory 1920 (1916).

divergence of the primitive stock into the Neandertal, Piltdown, and *sapiens* stems occurred early in the Pliocene, and that the differentiation of *H. sapiens* himself into the four great ethnic groups, African, Australian, Mongolian, and European, occurred before the beginning of the Pleistocene. On this account he is perfectly able to accept a Pleistocene age at least for the men of the New World. Back of the Heidelberg man, the European record is blank, unless indeed Piltdown and Castenedolo be older. The last particularly Keith doubts.

Tertiary man. Professor Osborn in a recent number of the magazine, *Natural History,* describes at some length beliefs which he holds as the result of a visit to East Anglia last

summer. That visit led to a very firm conviction of the presence of Upper Pliocene or Tertiary man in England, as shown by his cultures. These are three, two of which (1) the pre-Crag industry (rostro-carinate flints) of Ipswich, and (2) the Foxhall flints of Ipswich, are placed in the Upper Pliocene, while (3) the giant flints of Cromer are considered of Lower Pleistocene age.

Supposedly associated with the Foxhall flints was found a human jaw which unfortunately cannot now be located. If it could be found and the certainty of association determined, it would far antedate both that of Piltdown and of Heidelberg. The figure which Osborn published of this jaw, from the original by Collyer in 1867, is remarkable in that it is the jaw of *H. sapiens,* if correctly drawn, and not primitive at all! But this is exactly what Keith's arguments would lead us to expect. With the apparent insufficiency of evidence, however, judgment as to the antiquity of our own species should be for the present withheld.

Summary

The recorded physical changes in prehistoric man are:

Increasing cranial capacity, with perfection of the brain, especially in that portion which is concerned with the higher intellectual faculties and with speech.

Change in skull conformation, heightening forehead, and lessening brow-ridges.

Reduction of jaw power and of dental arch, which results in the formation of the chin prominence.

Changes in the teeth, such as reduction of canines and loss of diastemata.

Stature increasing and becoming more erect, although the earliest known hominid, *Pithecanthropus,* was fully upright, pointing to great antiquity for this characteristic.

As yet there is no actual connection with ape-like forms ancestral to both the modern apes and man, but the table here reproduced (Fig. 10) gives a tentative view of implied relationships. Exploration in Asia now being carried forward under the auspices of the American Museum of Natural History will, it is hoped, yield additional light on the problem of human origins, for all of our evidence points to central Asia as the birthplace of mankind, and to the Miocene, 1,000,000 to 2,000,000 years ago, as the time of his origin.

The antiquity of man has thus been made known by *direct* evidence in the form of human relics, the greatest age of which can hardly be less than half a million years. *Corroborative* evidence lies in the great variation, not alone between the several species of prehistoric man, but also among the many races of *Homo sapiens* himself, of which Gregory recognizes twenty-six, with a number of sub-races. And that the major divisions are very old is attested by ancient murals and other documents of the Egyptians and other oriental peoples.

Man's distribution is world-wide. In these days of easy travel, this is not so significant as it was in the ancient days when dispersal meant slow tribal migrations sometimes covering generations of time.

The intelligence of man so far surpasses that of his nearest competitors, the anthropoids, that the mental gulf between them is immeasurable, while the moral and spiritual attributes of mankind were also long in the making.

Communal life, as contrasted with the much more common herding instinct of the gregarious, has been attained but twice, among the social insects and among men. A long period of time is again necessary for this attainment.

Finally, man's remains, or the products of his industry, are found associated with numerous extinct creatures, of which he alone survives.

CHAPTER II

THE NATURAL HISTORY OF MAN

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The fundamental structural unit in man and other organisms is a microscopic mass, called a cell, which varies considerably in shape and size, and possesses a central spherical body, termed the nucleus. Animals composed of a single cell are called protozoa, those made of many cells, metazoa. Man is a metazoan and it has been estimated that his body is composed of more than twenty-six trillion cells. Animals without a longitudinal, dorsal body axis are called invertebrates while those with such an axis are known as vertebrates. Man has such an axis and also possesses other characters common to the vertebrates, such as a bony cavity, dorsal to the body axis, for the hollow central nervous system, and also an internal, segmented skeleton as shown in the serial repetition of ribs and vertebræ. Man is also a mammal in that he possesses mammary glands and hair and has the thoracic cavity, containing the heart and lungs, separated from the abdominal cavity by a complete diaphragm. Because of structural similarities he belongs to the order of primates together with the lemurs, monkeys, and apes.

Structurally man differs from his nearest relatives, the anthropoid apes, by differences of degree rather than of kind such as the better adaptation of his feet and vertebral column to the upright position, the non-opposability of the great toe,

the greater size of the cranium and the brain, the relatively smaller and less projecting face, and the relatively and absolutely longer lower extremities. Man does not differ much more from the tailless apes, like the gorilla, than they differ from the old-world tailed apes.

Anthropologists generally agree that living man is represented by one genus *Homo* and a single species *sapiens,* and that the various races are merely varieties of *Homo sapiens.* Fossil remains of man have been found, as has been explained in the previous chapter, which represent several other species and which show marked ape-like characters. It is not certainly known whether present man has evolved through these fossil forms or whether they rather represent collateral lines now extinct.

The races differ notably in many parts of their bodies. The most important differences are shown in the size and form of the head, in the skeletal and physiognomic characters, in the color of the skin, the form and color of the hair, and the body proportions. There are also differences in the susceptibility to disease and, although less marked, psychic differences in the races, particularly as exhibited in the temperament. The soft tissues likewise show racial differences although little in regard to them is known. This subject offers a large field for further investigation. It is possible also that the races differ in protein reactions and hormones, as held by some authorities, a subject as yet quite unexplored.

Blumenbach's classification of the races is as satisfactory as any, although the use of a single criterion of race distinction, namely, skin color, is open to objection. Blumenbach classifies the races as follows: (1) Caucasian, having a white skin, (2) Mongolian, having an olive skin, (3) Ethiopian, having a black skin, (4) American, having a dark skin with more or less of a red tint, (5) Malay, having a brown or tawny skin. Some classifications include the Australians as a

separate race. Additional interest is given to this classification of the races as it corresponds in a general way to their geographic distribution as shown in Fig. 2.

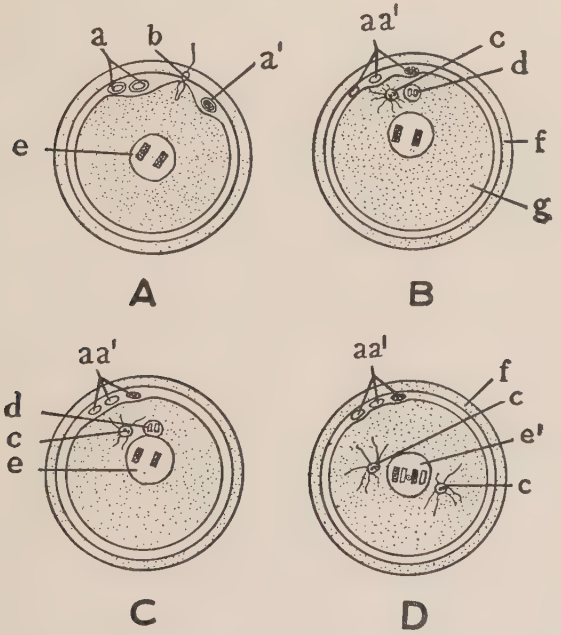

FIG. 11. DIAGRAM SHOWING THE FERTILIZATION OF THE OVUM

A, the mature ovum with a central nucleus, or, as it is termed, female pronucleus (e), containing the reduced number of chromosomes; the others have been given off into the first and second polar bodies (a a′). A single sperm (b) is entering the ovum. B, later stage in which the male pronucleus (d), with the two paternal chromosomes, has formed from the sperm. The sperm also brings to the ovum the centrosome (c), which is regarded as the dynamic division center. C, still later stage in which the male and female pronuclei are uniting to form, in stage D, the segmentation nucleus (e′), which contains an equal amount of maternal and paternal chromatin. Following this the fertilized egg cell will divide by the complicated process of mitosis which insures the equal division of the chromatin material among the daughter cells. a, first polar body (divided into two parts); a′, second polar body; b, sperm entering the ovum; c, centrosome (later divides); d, male pronucleus; f, cell wall; g, body of cell.

Redrawn from Cunningham, *Anatomy*.

Early Prenatal Development

Reproduction is started by the union of the germinal cells of the two sexes (Fig. 11). These cells are differentiated in development before the sixth week of prenatal life and set aside in special organs, the gonads, for the perpetuation of the race. Even at this early period the sex of the germinal cells of the embryo is structurally indicated. The female cell, or ovum, is spheroidal in shape and although it is one of the largest cells of the body yet it is so small as to be hardly visible to the naked eye. The male cell, or sperm, is very much smaller even than the ovum and is elongated and specialized for active motility. Both the sperm cells and the ova during their development go through a series of changes which result in the reduction to one half of the chromatin material contained in the nucleus. This is an important fact as the chromatin is regarded as the carrier of the hereditary qualities, and the fusion of these two cells at the time of fertilization, each with one half the normal amount of chromatin, produces again a complete cell with the typical amount of chromatin and having an equal proportion of maternal and paternal hereditary substance. As a result of fertilization the egg cell has the power of almost indefinite multiplication and the still more marvelous power of differentiation so that its descendants are not all alike, but some form nerve cells, others gland cells, still others muscle cells, et cetera. This differentiation in structure is accompanied also by a corresponding functional differentiation. It may be possible to explain many of the processes of life on the mechanistic, or physico-chemical basis, but it is difficult at present to explain reproduction on this theory.

After fertilization, the repeated multiplication of the egg cell quickly produces a solid spherical mass of similar cells, still almost microscopic in size, called the morula. Some of the cells soon become massed on one side and in this region two

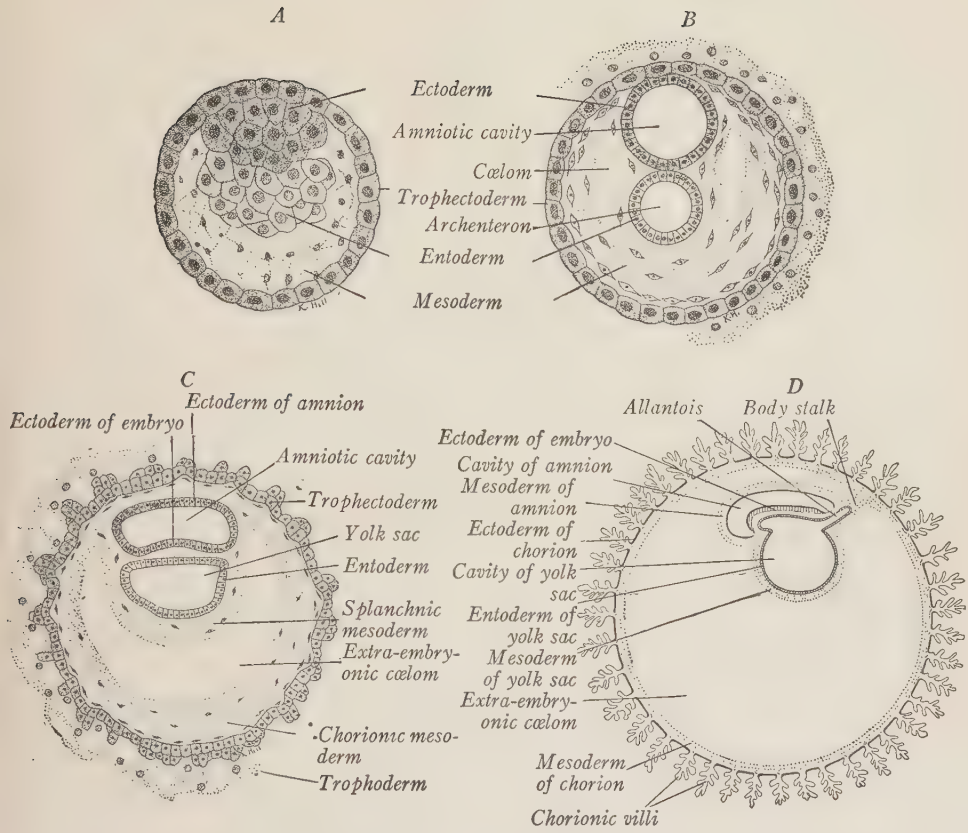

FIG. 12. DIAGRAMS OF EARLY HUMAN EMBRYOS

(Based on figures of Robinson and Minot.)

A. Hypothetical Stage.

B. Bryce-Teacher Embryo (modified).

C. Peter's Embryo.

D. Graf Spee's Embryo.

From Prentiss and Arey, *Embryology.*

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cavities develop (Fig. 12), one becomes the amniotic cavity and ultimately surrounds the embryo, and the other forms the yolk sac, part of which eventually becomes the alimentary canal. Some of the cells of the two sacs, which lie adjacent and are destined to develop the embryo, form two layers, known as the ectoderm and endoderm, or the external and internal membranes. This structural arrangement represents the earliest stage known in man's development, the previous stages described above being hypothetical and based on observations made on the developing eggs of other mammals. Later, through the multiplication of the ectoderm cells an elongated area, known as the primitive streak, is formed and this indicates the anteroposterior axis of the embryo.

Along this primitive streak, between the outer ectoderm and the inner endoderm layers, a third layer is produced, known as the mesoderm. We now have in the region where the embryo is developing, known as the embryonic area, three layers of cells, each having its own distinctive characteristics. These are known as the primary germ layers, and from them all the organs and parts of the body are later derived. In the human embryo all of the organs are formed by the third month of development. From the outer layer, or ectoderm, are formed the outer layer of the skin, or epidermis, including its various appendages such as the hair and sweat glands, the cells lining the mouth, the enamel of the teeth, and the entire nervous system including the sensory portions of the sense organs. From the middle layer, or mesoderm, are formed the skeleton and other supporting tissues and the muscles, the vascular system, and the sex cells. From the innermost layer, or endoderm, are developed the cells lining the alimentary canal and the essential secreting cells of the various organs which develop as outgrowths from it, such as the thyroid gland in the neck, the lungs, the liver, and the pancreas. In general it may be said that the endoderm supplies the ali-

mentary system; the mesoderm, the locomotor apparatus, and the sex cells for the preservation of the race; and the ectoderm, the nervous system which is placed in control of the body and puts man in touch with his environment. This method of development is essentially similar in other animals.

Up to this point the embryo appears as a rather simple multicellular animal of the invertebrate type. The first indication that it is to become a vertebrate is the development of a dorsal, longitudinal, rod-like axis, called the notochord, which eventually extends posteriorly from the base of the brain through the length of the body. In the lowest forms of aquatic vertebrates this is the only longitudinal supporting axis the body ever possesses, but in the higher fishes and the terrestrial vertebrates, where a more stable axis is necessary, the notochord is replaced by a more rigid, segmented, bony structure, the vertebral column.

The rudiment of the nervous system now appears, anterior to the primitive streak and dorsal to the notochord, as a longitudinal groove, known as the neural groove (Fig. 13), in the dorsal surface of the thickened ectoderm. The lateral edges of the groove become elevated and meet and fuse above it in the mid-dorsal line and thus form a hollow, ectodermal tube, called the neural tube. Practically the entire nervous system is developed from the cellular walls of this structure. Shortly afterwards a part of the yolk sac lying under the embryo is folded off and this process results eventually in the formation of an endodermal tube under the notochord which is the rudiment of the alimentary canal (Fig. 12 D).

Also the mesoderm, which at this stage is to be found lying along each side of the neural canal, becomes cleft transversely, beginning first just behind the brain, and this results in the formation of a linear series of segments, or myotomes (Fig. 14), extending the length of the body of the embryo. This primitive segmentation persists in a modified form in adult

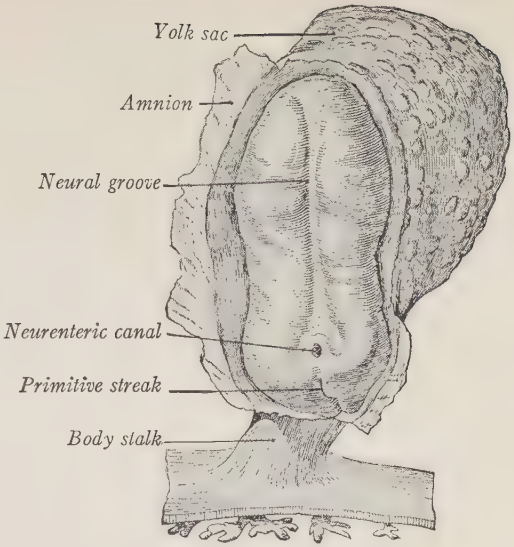

FIG. 13. HUMAN EMBRYO OF 1.54 MM. X 23.
(von Spee.)
The amnion has been cut away to show the neural groove.
From Prentiss and Arey, *Embryology*.
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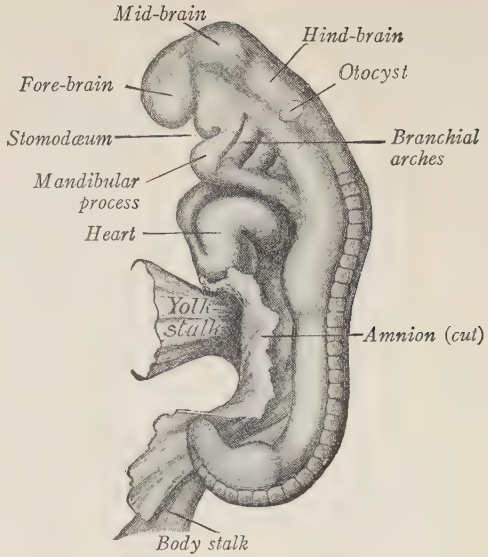

FIG. 14. HUMAN EMBRYO OF 4.2 MM. X 15.
(His.)
Lateral view, showing brain vesicles, branchial arches, between which are the gill clefts, and, to the right, muscle segments (myotomes).
From Prentiss and Arey, *Embryology*.
By permission of W. B. Saunders & Co.

man in the serial arrangement of the vertebræ, the ribs, and the spinal nerves. In the lateral mesoderm a cavity develops which is the beginning of the body cavity, or cœlom, and later contains the heart, lungs, and viscera of the abdomen. This cavity splits the mesoderm into two layers. The outer layer joins with the ectoderm to form the body wall, and the inner layer with the endoderm to form the wall of the alimentary canal which in time becomes entirely enclosed by the mesoderm and ectoderm of the body wall. The human embryo at this stage has acquired the characteristics of a typical vertebrate.

Later Prenatal Development

The Nervous System. The hollow neural tube early expands at its anterior end into three sacs (Fig. 15), the primary cerebral vesicles, or as they are often called the fore-, mid-, and hind-brain, and later the first and third sacs partially subdivide making altogether five enlargements. From the walls of these five sacs and from the remainder of the neural tube are developed all parts of the brain and spinal cord and nearly all parts of the cranial and spinal nerves which run to the peripheral regions of the head and body. The developing brain increases in length rapidly and bends in three places, the cervical flexure remaining permanently. A small sac grows out on each side of the hollow anterior brain vesicle and ultimately forms the retina of the eye (Fig. 15), which is thus a part of the brain projected to the surface of the head so the light can reach it. By thickenings, thinnings, and outgrowths, in different parts of the walls of the cerebral sacs, and by the development of myriads of nerve cells and fibers growing in many directions, the various parts of the brain are ultimately formed. Another sac grows out from each side of the forebrain in front of the developing retina which (Fig. 15), in man especially, possesses the power of extensive growth. This sac expands in all directions but especially backward, spreading

over the rest of the brain tube, and ultimately forming the cerebrum, which is so large in man in comparison with the lower animals. All of this sac, except the lower part, as well as the parts of the adult brain formed from it, is known as the mantle, or pallium (Fig. 16), the olfactory portion of which is the archipallium since in evolution it is the oldest part of the brain, while the rest, being a more recent addition, is called the neopallium. The latter is most extensively developed in man and forms the major part of the cerebrum.

The early condition of the neopallium in man represents about the extent of the pallium in the adult fish (Fig. 16). As it grows further backward it represents first the extent of the pallium in the next higher class of vertebrates, the amphibians, and later the extent in reptiles. Finally, as it begins to cover the cerebellum, we have the extent of the pallium as found in lower mammals and when it covers the cerebellum completely we have the human pallium. Thus we see that the pallium in its development in man passes through successively the various stages represented in the adult forms of the different vertebrates, starting with the fish and terminating with the mammalian type (Fig. 16). Similarly the structural unit of the nervous system, the nerve cell, or neurone (Fig. 17), passes in its development in man from the very simple neurone of the fish through the increasingly complex forms of the various vertebrates to its greatest complexity in man.

The sensory nerves (Fig. 18), which connect the skin and the various peripheral sense organs to the central nervous system, develop by a separation of serial groups of cells from the dorsal portion of the neural folds. From each of the cells in these groups two processes grow out. One grows into the central nervous system and the other pushes its way among the cells of the embryo until it reaches the sensory structures at the periphery. The motor nerves (Fig. 18) which control the muscles, on the contrary, grow out from cells situated in

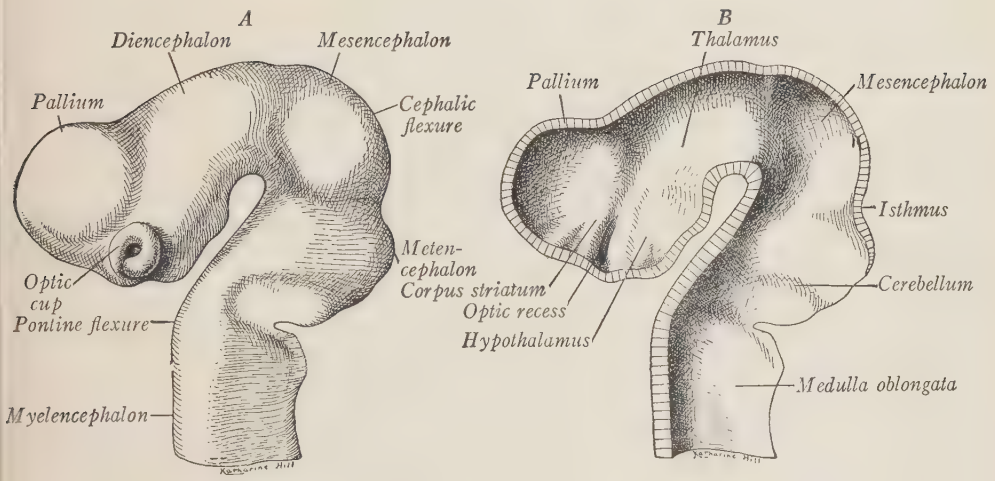

FIG. 15. DEVELOPING HUMAN BRAIN

From a 7 mm. embryo, showing the vesicles.

A, lateral view; B, median sagittal section. The fore-brain consists of the telencephalon (region labelled pallium) and diencephalon; the mid-brain consists of the mesencephalon, and the hind-brain of the metencephalon (cerebellum) and myelencephalon (medulla oblongata). The portion of the fore-brain which becomes the retina of the eye is indicated in A as the optic cup.

From Prentiss and Arey, *Embryology.*

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the anterior part of the spinal cord and thread their way among the embryonic cells till they reach the proper muscle, where they break up into fine fibrils which become embedded in its fibers. Nerve fibers, therefore, are merely the very elongated processes of nerve cells. How these fibers are directed to their proper terminations among the myriads of cells, whether by chemical attraction or other force, and so seldom go astray, has never been determined.

Before the nerves function they become surrounded by a translucent covering, called the myelin sheath, which is assumed at different periods during development, in the various parts of the spinal cord and brain. In general the myelin sheaths are assumed first by the peripheral sensory and motor nerves, thereby completing the reflex mechanism which in man occurs at about the sixth month of prenatal life. Following this the different groups of cells in the spinal cord are associated by the development of the myelin sheaths on the connecting nerves, thus arranging for association of the reflex actions. Still later the nerves connecting the spinal cord with the cerebellum myelinate, thus completing the mechanism for coördination of movements. Then the afferent nerves, which connect the spinal cord with the brain, assume their myelin sheaths, thus preparing the pathway for sensory impressions. Not until after birth, however, are the efferent tracts connecting the cerebrum and spinal cord myelinated, thus placing the cerebrum in control of the parts below and completing the motor pathway. This late completion of the motor tracts in man explains the great helplessness of the human infant at birth, a condition which is in striking contrast to that in many of the lower animals. It is believed that the assumption of the myelin sheaths in the various association tracts of the cerebrum continues during the period of growth and perhaps until forty years of age. As no brain cells are ever formed after birth, the increasing myelination of the nerve fibers is the chief struc-

tural change in the brain that can be correlated with the educational process.

The Eye. The eye develops from three sources. The retina, as noted above, is a direct outgrowth from the forebrain on the side of the head. The lens is an ingrowth from the ectoderm, and the sclerotic and choroid membranes, which form protective coverings enclosing the retina, are mostly differentiated from the mesoderm. Up to the sixth month of prenatal life a membrane stretches across the pupil of the eye which sometimes fails to disappear and thus causes blindness. Also the eyelids are grown together until about the same period, but in man, unlike the condition in certain other animals, such as kittens, a separation of the lids occurs before birth.

The Ear. The internal ear forms as a saccular ingrowth from the ectoderm on the side of the head. This invaginated sac becomes greatly modified but eventually forms the semicircular canals, which preside over the function of equilibrium, and the highly developed cochlea which is concerned with hearing. The internal ear is regarded as a specialization of a part of the lateral line sensory organs of the lower vertebrates, which in the fish is concerned with balancing and movement only. The added cochlea, which is present in terrestrial animals, forms the organ of hearing.

Alimentary Canal. The alimentary canal, as stated above, is early folded off from the yolk sac as a tube lying under the notochord of the embryo. Both ends of the tube are closed for a time, but long before birth an anterior and posterior connection with the external surface of the embryo has been made. At the anterior end of the body on each side of the neck, four crevices (Fig. 14) appear in the early embryo which, in the lower vertebrates such as the fish, open directly into the pharyngeal region of the alimentary canal and form the gill clefts. In man, however, these crevices never go on to the

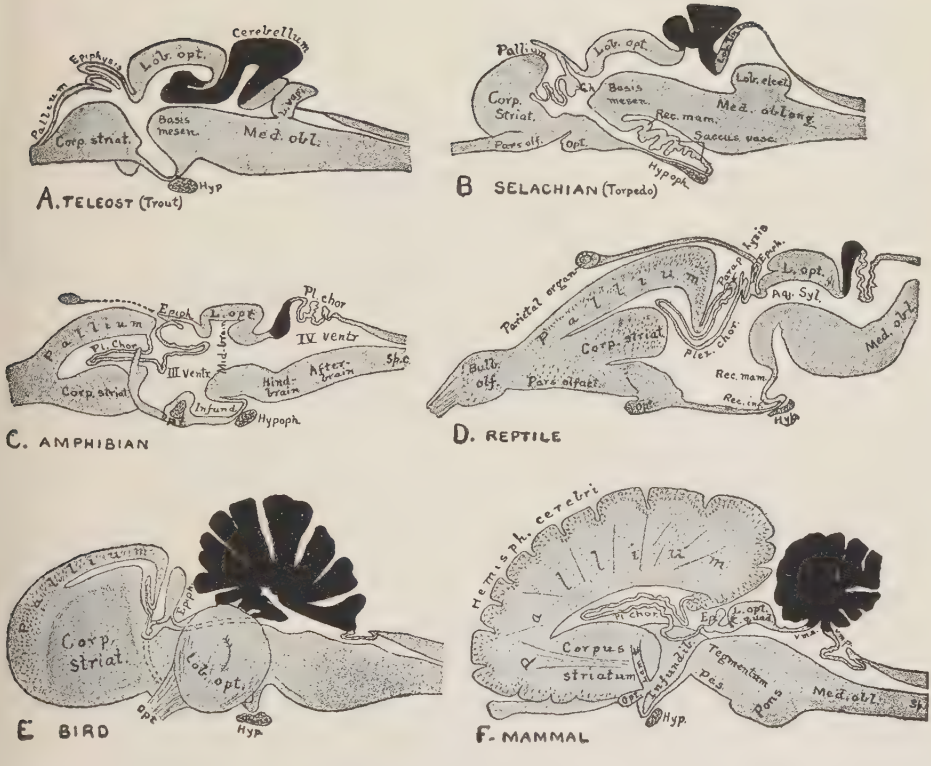

FIG. 16. THE PALLIUM AND CEREBELLUM IN THE BRAINS OF VARIOUS VERTEBRATES

The cerebellum is in black.

After Edinger. From Bailey and Miller, *Embryology*.

By permission of William Wood & Co.

formation of gill clefts but soon disappear. Their presence, however, is indicative of a fish stage in his development. The lungs, which are the permanent respiratory organs (Fig. 19) of man, are developed from the upper end of the alimentary canal by the formation of a single hollow sac. This later

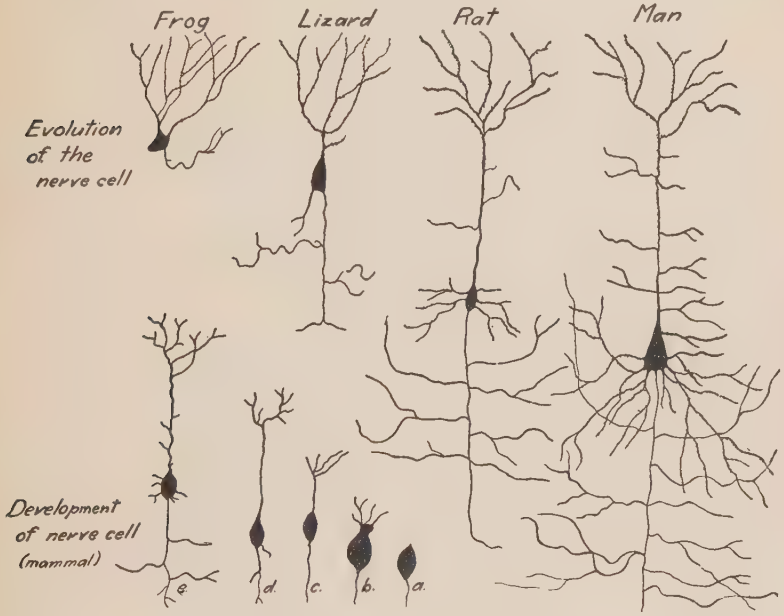

FIG. 17. THE NERVE CELL
Its individual and evolutionary development.
After Cajal.
Redrawn from Donaldson, *The Growth of the Brain.*

bifurcates to form the rudiments of the right and left lungs and these by repeated branching develop the highly ramified, tubular structure of the adult lungs. The early simple, sac-like lung of the human embryo is similar in structure to the permanent, saccular lung of the adult amphibians.

From the neck region of the alimentary tube, three other organs develop as branching outgrowths, all of which finally form organs of internal secretion, namely the thyroid, the

parathyroid, and the thymus glands (Fig. 19). Another important endocrine organ, the pituitary body, or hypophysis, has a double origin in that a portion of it develops as an upgrowth from the ectoderm which lines the extreme anterior end of the alimentary canal, or buccal cavity, and another portion, which fuses with the former, develops as a downgrowth from the brain. These glands, through their internal secretions, or hormones, influence development in various ways. All of them ultimately lose their connection with the alimentary canal. The thyroid gland moving down the ventral side of the neck stops just above the thorax. The thymus, which in the calf is commonly called the sweetbread, descends into the thorax until it lies just above the heart. Early in prenatal life the glandular structure of the thymus disappears and a lymphoid tissue, such as we find in the tonsils, takes its place. This organ continues to grow until the child is about two years of age and then gradually diminishes in size, disappearing at about twenty years of age. This same remarkable history of the thymus is found in other mammals as well as in man. Little is known definitely with regard to the function of this organ.

Lower down the alimentary canal, just below the spindle-shaped enlargement which represents the developing stomach, two other organs grow out and, by repeated branching, form the liver and pancreas (Fig. 19). These always remain in connection with the alimentary canal by ducts which carry their secretions. The pancreas develops as two outgrowths which fuse. Usually only one of the ducts persists. Occasionally it is found in man that both persist and the pancreas pours its secretion into the intestine by two ducts instead of one. The explanation of such cases undoubtedly lies in the double origin.

The Vascular System. The heart differentiates from a portion of the mesoderm lying underneath the pharynx in the head region of the embryo. Two straight tubes are first formed (Fig. 20). These quickly fuse for part of their length form-

FIG. 18. SPINAL NERVE

Transverse section through the spinal cord of a 76-hour chick embryo showing early development of a spinal nerve.

A, motor root; B, sensory root; C, bifurcation of fibers of sensory root; a, b, c, d, neurones in various stages of differentiation.

After Cajal. From Bailey and Miller, *Embryology*.

By permission of William Wood & Co.

ing a single tube which is bifurcated at each end. At this stage of development, the human heart resembles that found in the adult of the lowest vertebrates. Later the single tube of the developing heart partially subdivides into two cavities, the auricle and the ventricle, and it now resembles the heart of the adult of the next higher vertebrates, the fish. The auricle is then subdivided into two cavities, and the human heart of three cavities resembles the fully developed heart of the next higher vertebrate, the amphibian. Later the ventricle is subdivided and the human heart contains four cavities, which is characteristic of the adult heart of the highest vertebrates. Thus it is evident that the human heart in its development passes through stages representing the different adult stages of the various ascending vertebrate classes. This again is an illustration of the so-called Law of Recapitulation, which holds in essence that man in his individual development repeats the evolutionary history of the race, or that "ontogeny repeats phylogeny."

The blood vessels, consisting of the arteries, capillaries, and veins, are tubes which differentiate from the mesoderm cells in all parts of the body and become connected with the heart. The blood cells, which are present in countless numbers in the blood, likewise are derived from mesoderm cells, and we find that the red blood cells of the human embryo when first formed are large and nucleated. In this stage they resemble those of the fishes and amphibians; later their structure is similar to those of the reptiles. Finally, before birth, they become in man, as in all mammals, non-nucleated and biconcave.

The complete natural history of the human red blood corpuscles has never been learned. It is known that they are constantly formed in the adult from the cells of the red marrow in the ends of the long bones and that they are nucleated at first but lose their nuclei before they enter the circulation. Although it is believed that the corpuscles are constantly being

destroyed, little is known as to where or how the destructive process occurs. Sometimes they seem to be destroyed much faster than they are formed and this results in a great reduction of the number of the red blood cells of the body from

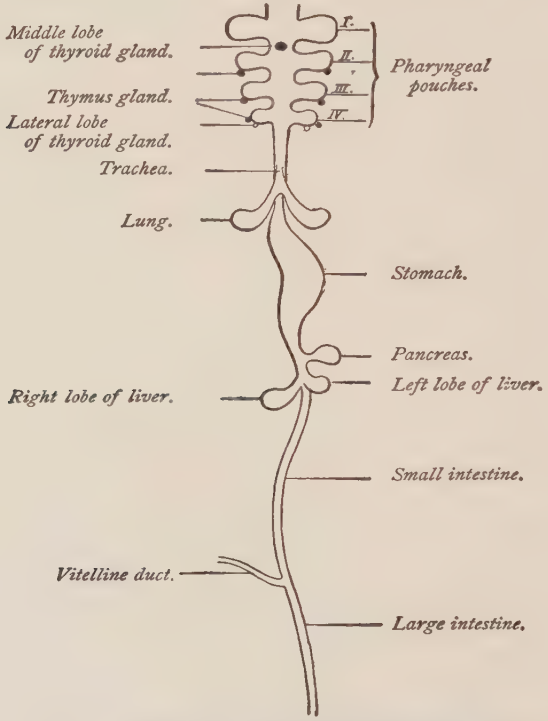

FIG. 19. ORGANS DEVELOPING FROM THE RUDIMENTARY ALIMENTARY CANAL

After Bonnet. From Heisler, *Embryology*.
By permission of W. B. Saunders & Co.

5,000,000 to perhaps 1,000,000 per cubic millimeter, together with the appearance also of a certain number of the embryonic type of nucleated red cells in the blood stream. Evidently the immature cells are drawn into the blood stream in the endeavor to make good the excessive loss. This is the condition which exists in that quite fatal disease, pernicious anæmia.

Reproductive System. The gonads, in which the germinal cells form, are developed in the body cavity just at the lower end of the kidneys, probably from mesodermal cells, and early begin to move downward in the abdomen. In the female they go as far as the pelvic cavity where they remain. In the male they pass through a canal in the lower part of the abdominal wall, called the inguinal canal, to the exterior of the body. Similar migrations of the gonads occur in most mammals. The reasons for these migrations are not known, but the inguinal canal remains as a weak spot in the abdominal wall and under special stress may permit loops of the intestines to pass through, thus forming a hernia. This is the penalty man is still paying for the lack of structural adjustment to the upright position.

The external genital organs develop in a similar way in both sexes and no structural distinction is to be observed until near the beginning of the third month of fetal life. At this time the indifferent sex condition begins to develop into one sex or the other by the greater growth of some parts and the partial suppression of others, depending upon the sex to be formed. In rare cases the indifferent condition of the sex organs may persist permanently in either sex, a condition known as spurious hermaphroditism, which has particular interest to criminologists and sociologists. The urinary system develops in close relationship to the genital system and, before the permanent adult condition is reached, passes through a remarkable series of changes, many of which are typical of the permanent adult condition in the lower vertebrates.

The Muscles. As noted above, the mesoderm, which lies along each side of the developing spinal cord, becomes transversely divided into a linear series of segments (Fig. 14). This process begins when the embryo is about two weeks old and continues until a total of thirty-eight segments are formed which extend the entire length of the embryo. From these

segments are developed all the muscles of the body, the axial part of the skeleton, and the membranes surrounding the brain and spinal cord. Although the muscles are at first

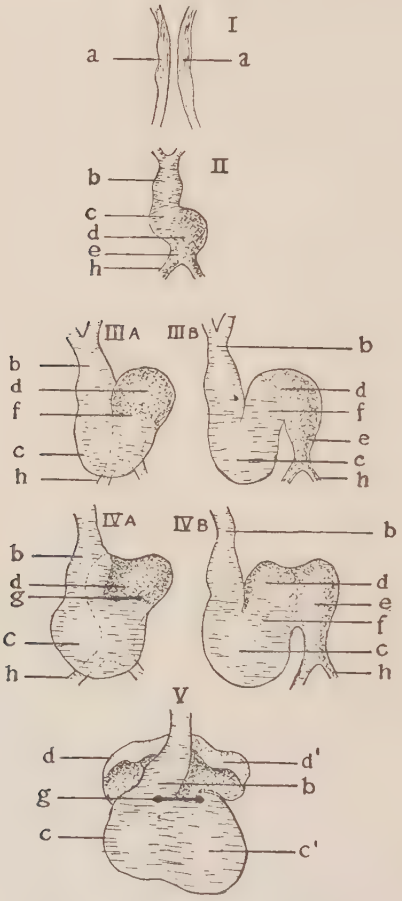

FIG. 20. THE HUMAN HEART

Diagram showing its development and changes of form and external appearance at different stages.

Modified from His's models.

Figs. IIIB and IVB are side views; the others are front views. a, primitive ventral aorta; b, bulbus cordis; c, ventricle; c′, left ventricle; d, auricle; d′, left auricle; e, sinus venosus; f, atrio-ventricular canal; g, position of orifice of atrio-ventricular canal; h, vitelline vein.

Redrawn from Cunningham, *Anatomy*.

separate masses, by a process of fusion of the segments and then a later splitting, either lengthwise or tangentially, the long, flat muscles in the front and back of the body are formed. Also many muscles shift from their early positions to some quite distant place. This is the case, for example, with the muscular diaphragm, which forms in the neck and is supplied by a nerve from this region but which, during development, moves posteriorly dragging its nerve with it, until in the final position it separates the thorax from the abdomen. All of this differentiation and shifting of muscles has been completed some time before the child is born and therefore is not produced by any functional necessities after birth, but is due to heredity.

The Limbs. Until the beginning of the fourth week of development, man is a limbless vertebrate (Fig. 23). The rudiments of the limbs then grow out as buds from the side of the body and, as they elongate, five projections appear at the end of each of the buds which represent the developing fingers and toes. This peripheral cleavage into five parts perhaps is representative of the five main segments of the body from which the limb projects. Inasmuch as the five-fingered, or pentadactyl, limb is the common vertebrate type it is believed that polydactylism, or an extra number of fingers or toes, is not a reversion to an ancestral form but is due to an unknown cause.

The Skeleton. The skeleton is preceded in very early prenatal life by two kinds of material, cartilage and membrane. While most of the bones of the skeleton are ossified from cartilage, the bones of the cranium are largely developed from membrane. The cranial bones begin ossification at their centers near the end of the second month of prenatal life, the growth of the cranium being due chiefly to additions at the edges of the bones. In the long bones, like the femur and humerus, which are mapped out in cartilage, the centers of

ossification appear about the eighth week of prenatal life in the center of the shaft, and, at birth, while the shaft is bone, both extremities are still cartilaginous.

The Skin. The outside portion of the skin, or epidermis, is derived from the ectoderm, while the deeper portion, or dermis, is developed from the mesoderm. The human skin at the end of the second prenatal month is translucent and has many points in common with that of fishes and amphibians. In the third month a delicate, superficial, horny stratum appears, a stage which has been held to represent the evolution from an aquatic to a terrestrial form of life.

Hairs are outgrowths from the epidermis and are developed in groups and lines. Their arrangement can best be explained on the supposition that originally the skin was covered by scales and that the hair grew out in groups at their tessellated junctions as is found in certain of the edentates. The skin of man, in comparison with that of the other primates, is comparatively hairless, which is probably a recently acquired character. At the seventh month of prenatal life the chimpanzee and gorilla have well-developed hair on the scalp, eyebrows, and lips, while the rest of the body is covered with fine hair. This is also the condition of the human fetus at a corresponding period. The hair slopes in man are also very similar to those of the apes. Some hairs, such as those present in the eyebrows, perhaps originally had a sensory function and, in general, hair appears to be a modification of certain glandular and sensory structures found in the skin of the amphibians. Evidence has accumulated which shows that the development of the hair is regulated, at least to some degree, by an internal secretion of the thyroid and sex glands.

Face and Nose. The face is developed from a series of paired processes surrounding the primitive mouth (Fig. 21). These grow in from the sides toward the mid-ventral line where they normally fuse by the third prenatal month, by a

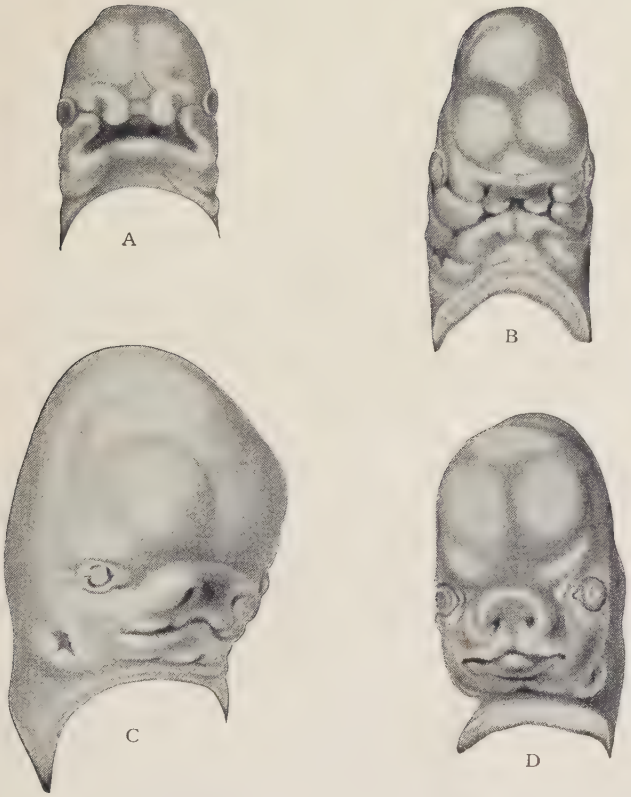

FIG. 21. DEVELOPMENT OF THE FACE OF A HUMAN EMBRYO
(His.)
From Prentiss and Arey, *Embryology.*
By permission of W. B. Saunders & Co.

method somewhat akin to the healing of wounds, to form the nose and lips. A failure of proper fusion of these processes results in harelip and various other facial deformities.

In the development of the human nasal cavity a recapitulation of the conditions present in the various classes of vertebrates is to be noted. At the end of the third week of fetal life the rudiments of the olfactory organ appear as two thickened plates of ectoderm which are in contact with the under surface of the fore-brain. A week later these plates become depressed and are found at the bottom of the olfactory pits. This condition is similar to that found in fishes. Two weeks later the depression has deepened and a nasal cavity is formed which is somewhat similar in structure to that found in the air-breathing or lung fishes. By the seventh week this primitive nasal cavity has rapidly enlarged and a communication has been made with the mouth as in amphibians. The mammalian condition is reached by the third month. At this time the roof of the mouth is completed by the growth to the center and fusion of two lateral shelves. A failure of these shelves to unite produces cleft palate.

The teeth are formed by local outgrowths of the ectoderm and mesoderm lining the mouth, the enamel being formed from the ectoderm, and the dentine and pulp from the mesoderm. The human molars with their several cusps have evolved from the simple conical teeth of fishes and reptiles either by a process of partial fusion or by an outgrowth of cusps from the conical tooth.

The Prenatal Nourishment of the Embryo. During prenatal life the fetus is enclosed in a fluid-filled sac, the wall of which is composed of two membranes, the inner called the amnion and the outer the chorion, which serve for protection and nutrition (Fig. 12). The development of an embryo *in utero* is dependent upon its ability to secure nourishment and to eliminate certain wastes. In order to do this it must get

into contact with the maternal blood supply in the walls of the uterus. It appears that, in this early stage, the outer layer of embryonic cells is able to secrete a ferment, or enzyme, which actually eats away, or digests, a portion of the uterine wall with which it is in contact. This process furnishes the embryo with a temporary supply of food which can be absorbed by the cells and also enables it to imbed itself completely in the uterine wall where it is surrounded with extravascular blood, the result of the erosion of maternal blood vessels. In a short time a certain region of the outer layer of cells together with the underlying chorion becomes modified to form a highly specialized structure, the placenta, through which an interchange of materials between the mother and embryo can take place. The fetal placental tissues become actually fused with the uterine wall (Fig. 22), and the underlying tissue of the latter is gradually eroded to such an extent that the finger-like processes, or villi, of the fetal tissues of the placenta, which project into the maternal tissue, are surrounded by intervillous spaces of considerable size which are filled with the maternal blood (Fig. 22). Although the placental villi are richly supplied with fetal blood vessels there is never any direct connection between the maternal and fetal blood vessels in the placenta, and no nerves pass from the mother to the child. The interchange of materials, oxygen and food from the maternal to the fetal circulation, and carbon dioxide and liquid metabolic wastes from the fetal to the maternal, all takes place by osmosis and specific selection. The structure of the placenta in the different mammals shows considerable variation. That found in the anthropoid apes is very similar to the human type.

The maternal and fetal blood streams are separated by the embryonic tissue of the placental villi (Fig. 22). This separation can be proved by the microscopic examination of the contents of the fetal vessels in the placental villi and the maternal

blood in the placental sinuses in the early stages of development. Many nucleated red corpuscles which are found only in the blood of the fetus will be seen in the vessels of the placental villi but there are none in the placental sinuses. Further, the vessels in the placental villi can be injected from the fetal but not from the maternal blood vessels.

That gases can be transmitted from the maternal to the fetal circulation is shown by the fact that the blood in the umbilical vein, which carries blood from the placenta to the fetus, is redder and contains more oxygen than the darker blood of the umbilical artery, which carries blood from the child to the placenta. Also ether or chloroform administered to the mother can be demonstrated in the blood of the child.

Substances in solution also can pass from the maternal to the fetal blood. This is indicated by the fact that the child grows. Also it has been experimentally demonstrated in the case of many drugs that when they are administered to the mother they will be found in the blood of the child. Among these drugs are bromide of potassium, arsenic, strychnine, quinine, and morphine.

The work of recent observers seems to show that fats and proteins are not passed unchanged through the walls of the placental villi from maternal to fetal blood, but are broken down into simpler compounds and later recombined, thus making the process of absorption in the placenta somewhat analogous to that occurring in the intestine. The placental tissue apparently has not only the power to change some substances but also the power of specific absorption. Proteolytic, lipolytic, and glycolytic ferments have been demonstrated in the placental villi, also a ferment which changes certain of the amino acids into ammonia.

Observers now generally agree that, while the placenta usually acts as an efficient filter against bacteria, occasionally bacteria may be transmitted from mother to child as has been

known to occur in some cases of typhoid fever and, in rare instances, of tuberculosis. On the contrary, it has been demonstrated that the toxins and antitoxins of diphtheria, tetanus, and typhoid fever readily pass from the maternal to the fetal blood stream in the placenta. Furthermore, biologists agree that there is no foundation for the more or less general belief that maternal impressions are responsible for malformations of a child. It can be understood, however, that a general disturbance of the fundamental metabolic processes in the mother may result in similar disturbances in the fetus and thus may interfere with the normal developmental processes.

Birth. It has been seen that the human embryo is a parasite which engrafts itself on the maternal tissues and by the remarkable and highly specialized organ, the placenta, is supplied with nourishment and relieved of its wastes. This connection is normally retained for a period of approximately nine months, at which time the 'host,' for reasons largely unknown, refuses longer to support the 'parasite.' Rhythmic contractions begin in the walls of the uterus. These increase in strength and frequency and finally result in the birth of the child. In separating the placenta and tearing the large maternal vessels of the uterus, without causing an excessive hemorrhage, nature performs a wonderful surgical operation. The moment the child breathes and the lungs expand, the course of the circulation is changed. This change is due to the expansion of the lungs and the consequent large flow of blood to them. As the result of this, the opening between the two auricles (*foramen ovale*) closes, the course of the circulation in the heart is also changed and the blood, which was formerly aërated in the placenta, is now aërated in the lungs. Sometimes this interauricular opening fails to close in the proper manner and this permits a mixture of venous with arterial blood which causes a dark color in the skin and, therefore, what is commonly known as a 'blue baby.'

In the prenatal condition the child needs to produce very little heat because so little is radiated and the mother supplies all of the necessary food and oxygen and removes all the wastes. After birth the radiation of heat is greater and the child is obliged to produce much more in order to maintain its body temperature. The alimentary canal must take in and digest its own food; through its lungs the child must obtain oxygen and free itself of carbon dioxide, and its excretory organs must remove its own wastes. It is evident, from the above, that there is a great contrast between the prenatal and postnatal environment, and the fundamental changes in circulation, nutrition, and excretion which occur at the time of birth make this period a very critical one for the child.

At birth the child weighs about seven pounds, and is twenty inches in height. Its upper extremities are relatively long, and the lower extremities short. The legs are partly flexed, the great toe abducted and the soles of the feet turned in. The latter is believed to be indicative of a persistence of the climbing position which existed in arboreal man. Additional evidence along this line is to be found also in the remarkable power of the hand grip of the child during the first month of its life. At this time the infant is able to hold its weight suspended by its hands, a power which is later lost. When the body proportions of the newly born child are compared with those of the adult it is found that the child is four times its head height while the adult is eight times; that the upper and lower extremities of the infant are equal in length while in the adult the lower extremities are longer than the upper. The long arms, short legs, flat nose, inverted feet, and lack of cervical and lumbar curves in the spinal column of a newly born infant constitute a remarkable series of structural resemblances to the ape which later disappear as the adult condition is reached. The child at birth can feel, see, taste, and suffer pain but it is deaf for about twenty-four hours. Its

most striking characteristics, in contrast to the lower animals, are its helplessness and educability. Its helplessness has undoubtedly been an important factor in the development of the family, while the long period of growth before maturity is reached has exerted a great influence in the development of man's psychic powers, which distinguish him so markedly from all other animals.

Statistics of various animals show that the proportion of male and female births is approximately equal; the ratio in man being about 106 males to 100 females. Multiple births are the usual rule in most of the lower mammals but not in the primates. Occasionally, however, it occurs and in man even sextuplets have been recorded. There have been some 500 theories proposed as to the cause of sex determination and as to methods for controlling it, but the accumulated evidence of the last few years clearly shows that sex is determined at the time of fertilization, just as are all somatic characters, and that it cannot later be changed by any means. Inasmuch as the ossification of the bones of a female embryo precedes slightly that of the male embryo, a radiograph may perhaps aid in ascertaining the sex of the child before birth.

If we summarize the facts regarding man's early development, which are given above, it is evident that he starts his development as a unicellular animal, becomes a metazoan of the invertebrate type, develops the structure of a vertebrate, and ultimately becomes a mammal. Many of the structures of his body pass through temporary stages which are typical of the adult condition in various classes of the vertebrates and, in general, his organs are developed in a manner similar to that in other animals. Man's development, however, parallels that of the anthropoid apes for a longer time than that of other mammals and at birth the child has ape-like characters that later disappear. These facts of human development associate man closely with the anthropoid apes and give evi-

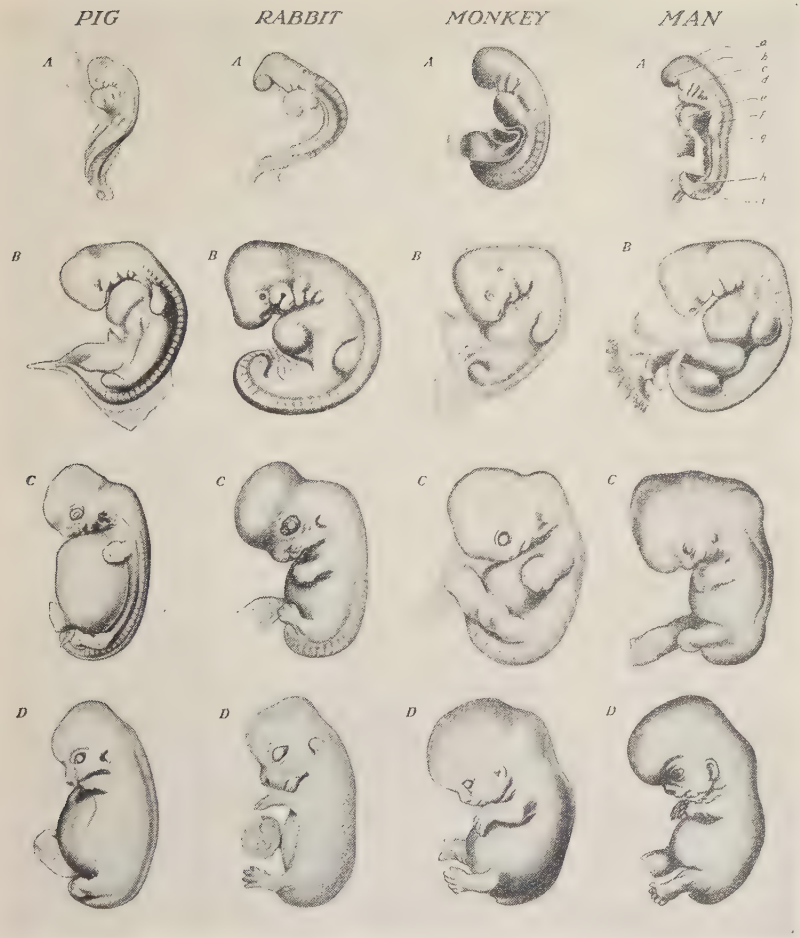

FIG. 23. EMBRYOS OF THE PIG, RABBIT, MONKEY, AND MAN

Comparison at corresponding stages of development. The embryos of each animal are arranged in the vertical columns according to age, beginning with the youngest stage at the top. Stage A of the human embryo is fully labelled, and the corresponding structures in the other embryos can be noted.

a, head region; b, eye; c, ear; d, gill slits; e, heart; f, fore limb; g, primitive muscle segments; h, hind limb; i, tail region.

Slightly modified from K. Guenther, after Keibel.

dence that the latter reproduce, in many respects, a comparatively recent phase in the history of human evolution.

Postnatal Development

In the final analysis, growth in any living organism is the result of the division of a cell into two daughter cells each of which, when first formed, is half the size of the original cell. The daughter cells very soon, by the process of intussusception which undoubtedly involves complex physico-chemical processes, grow to the size of the original cell and then the process can be repeated. In prenatal life, the embryonic cells, in general, divide comparatively rapidly and, as a rule, are not as large as in postnatal development. The increase in size after birth is believed to be due primarily to a general increase in the size of the cells of the body rather than to the formation, by cell division, of additional cells. Development is therefore accomplished by cell division, cell enlargement, and cell differentiation.

The ultimate size of an animal depends both upon the rate and the duration of growth. Minot has shown that man becomes larger than the rabbit, not because of a more rapid growth, but because he grows for a longer period of time. The rabbit, on the other hand, becomes larger than the guinea pig because of a more rapid rate of growth. Large animals, with few exceptions, continue to grow during a longer period and live longer than do small animals. Statistical studies show that the rate of growth is most rapid in early prenatal life and steadily diminishes until birth. During the prenatal period of the human embryo the weight increases more than 5,000,000 times, while after birth the increase is only 20.6 times. As the rate of growth is a constantly decreasing one, its cessation seems to be the final term of a diminishing series. During the most rapid period of growth the cells have large nuclei but, with advancing age, the cytoplasm relatively

increases and this change in the relative size of nucleus and cytoplasm constitutes the chief structural difference between the cells of the young and of the old. A decreasing rate of growth is also accompanied by a diminution in the water content of the body, as is shown by the fact that in the first month of prenatal life the percentage of water in the body is 97.5 per cent, at birth it has become 74.7 per cent, and at maturity 58.5 per cent.

While man and the higher vertebrates have a definite period of growth some fishes and amphibians continue to grow throughout life. The forces which stimulate or inhibit growth are largely unknown. Evidence is accumulating to show that certain of the internal secretions, notably those given off by the thyroid and pituitary glands, play a large part in the control of growth. It is believed that too much secretion of the latter may increase the growth of local areas of the body such as the hands and face. This condition is to be seen in the rare disease known as acromegaly. On the other hand, a diminished secretion of the thyroid results in a failure of growth of the entire body as well as a lack of mental development, a condition known as cretinism. Various factors such as unfavorable climatic conditions, poor food, lack of proper proteins and vitamines, and severe illness retard growth.

However, these factors do not offer any explanation as to why most animals stop growing after reaching the size of the species. A mouse never grows to the size of an elephant, nor does an elephant remain as small as a mouse. It is apparent that there is a fundamental hereditary factor involved which in some way, possibly through the internal secretions, controls growth. That this hereditary influence has not always remained constant is shown in the size variation of the same species in different geologic ages. This is notably shown in the evolution of the horse. The question of growth is closely associated with the power of regeneration, that is, the ability

of an animal to replace lost parts. The power of regeneration in an animal, in general, is found to be in inverse ratio to the degree of specialization, or differentiation, which it exhibits. For example, among the lower vertebrates, the amphibia are able to regenerate entire limbs, whereas in the more highly specialized animals such as man this power of regeneration is present only in certain tissues, notably the connective and epithelial, by the agency of which wounds are healed. Cancer is generally regarded as a localized lawless and unrestrained growth of epithelium, the cells having become parasites and attacked the host. The only cure thus far discovered is an early destruction or removal of the abnormal parasitic cells. The causation of cancer apparently lies in the disturbed balance of the forces stimulating and restraining growth in the affected cells and is probably essentially a faulty cellular chemistry.

The child sits up by the sixth month, creeps by the tenth month, and walks by the fifteenth month, thus passing from a quadrupedal gait to the erect position in a few months, an accomplishment which in evolution may have occupied ages. All parts of the child do not grow at the same rate and, as a result, the body proportions continually change during growth (Fig. 24). Even the shaping of the features is due to the different rates of growth of the various parts of the face. Comparing the condition at birth with that of maturity it is found that while the head doubles in height, the body increases three times, the upper limbs four times, and the lower limbs five times. These changes in the body proportions are well shown if, with the adult proportions, we compare the proportions of the child when expanded to the height of the adult. Such a comparison will show, as has been previously noted, that the head of the adult is relatively smaller, the arms shorter, and the legs longer (Fig. 24).

Likewise it is known that various organs grow at different

rates with the result that they bear a different ratio to the total body weight at different ages. Here is a field that needs much further study inasmuch as this changing relationship in size may have an important bearing on the incidence of disease at different ages. The studies which have been made on the

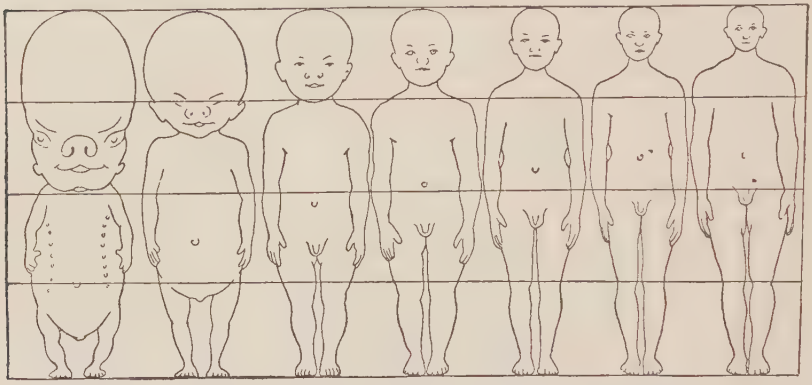

FIG. 24. CHANGES IN PROPORTION DURING PRENATAL AND POSTNATAL GROWTH
After Stratz. From Morris's *Human Anatomy*.
By permission of P. Blakiston's Son & Co.

relative growth of the different organs show that the same proportionate weight of the skeleton, fat, and skin, which is about 39 per cent of the total weight of the new-born, persists in the adult; that the relative weight of the organs of circulation, respiration, and alimentation is about twice as large in the new-born as in the adult; that the weight of the muscles of the new-born is relatively one half as large as in the adult, and, that the central nervous system of the new-born is relatively eight times as large as in the adult. It is possible that the very rapid growth of the brain in early childhood accounts in part, at least, for the nervous instability of that period.

Considerable data have accumulated with regard to the growth of bone. Membrane bones, such as certain bones of the

cranium, grow by additions along their edges which form the sutures. Beginning at about forty years of age, when the brain stops growing, the cranial sutures disappear. In the long limb bones in early postnatal life, one or more centers of ossification appear in the terminal cartilages and form caps of bone. The growth in length occurs in the cartilage under the bony caps. This was shown experimentally many years ago by John Hunter, who inserted shot in the shaft and in the end cap of a femur in a young animal, and later found that the distance between them had increased. Usually by the twenty-first year these caps have joined to the shaft thus making any further growth in length impossible. The growth in the circumference of a bone takes place by additions under the outer fibrous membrane, known as the periosteum. This has been shown experimentally by feeding growing animals with madder, which gives a yellowish stain to the new bone.

The child, like the young of all mammals, is born without teeth. The first set, twenty in number, begins to erupt about the sixth month after birth and is completed when the child is nearly two and one half years of age. During the next few years the permanent teeth, thirty-two in number, are forming beneath the temporary teeth and also behind them, and, by the absorption of their roots, replace them. The first permanent tooth to erupt is the first molar which appears behind all the temporary teeth at the sixth year. By thirteen years of age all of the permanent teeth have erupted except the third molars, or wisdom teeth, which appear about the seventeenth year. The latter may be small in size, be abnormally placed, appear late, or even fail entirely to appear.

A study of the growth curves for height and weight (Fig. 25), which have been plotted by averaging the results obtained from weighing and measuring many children at various ages, but mostly over five years of age, shows a general agreement of results. There is a loss of weight for the first few days

after birth, the postnatal retardation. During the first year, growth in both weight and height is rapid—the boy increasing

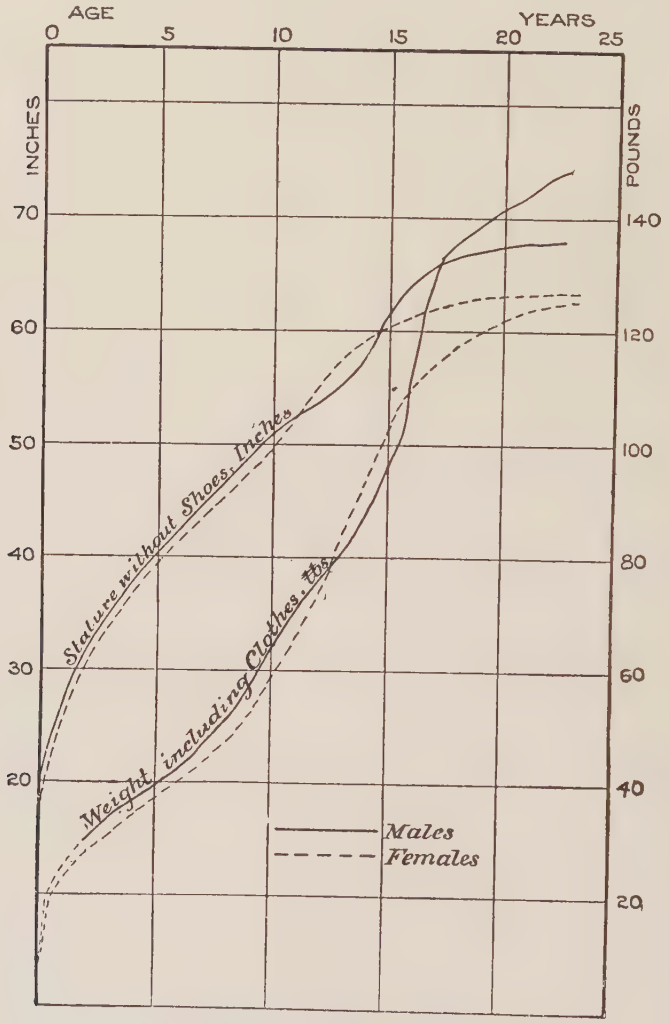

FIG. 25. GROWTH CURVES FOR INCREASE IN WEIGHT AND STATURE FOR BOTH SEXES
From Donaldson, after Roberts.

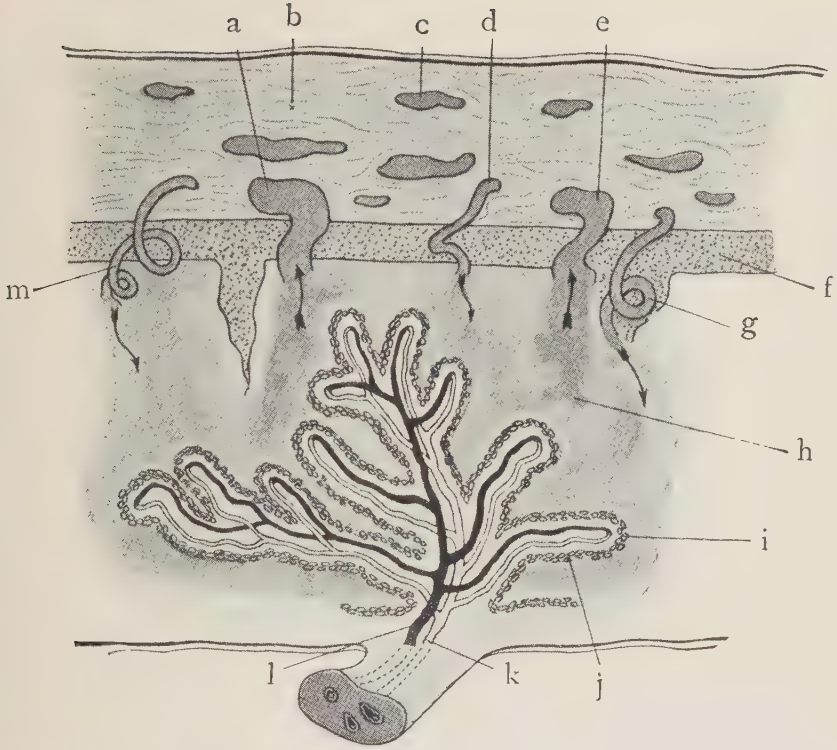

FIG. 22. THE RELATION OF THE FETAL TO THE MATERNAL BLOOD IN THE PLACENTA

Arrows indicate the supply and exhaust of the maternal blood in the large intervillous spaces.

a, sinus of uterine vein; b, muscle tissue of uterine wall; c, uterine vein; d, uterine artery; e, sinus of uterine vein; f, decidua basalis; g, uterine artery; h, intervillous space filled with maternal blood; i, syncytium; j, villus; k, umbilical vein (fetal); l, umbilical artery (fetal); m, uterine artery.

From Prentiss and Arey, *Embryology*.

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more rapidly than the girl—then the rate of growth goes on more slowly up to seven years of age. This is followed by a more rapid increase in growth rate up to about seventeen years in the boy and sixteen years in the girl, with a prepubertal acceleration present in both sexes. The growth rate then decreases to twenty-five years of age, at which time growth practically ceases.

During the early years the boy is slightly taller and heavier than the girl but, owing to an earlier prepubertal acceleration in the girl, the two sexes are equal in height at twelve years of age and for the next three years the girl is the taller. Similarly, at thirteen years of age, the two sexes are of equal weight and for the next three years, the girl is the heavier. After fifteen years of age the boy surpasses the girl in height and after sixteen years in weight. The average height for the people in the United States is about five feet and eight inches for men, and five feet and four inches for women. On the other hand some of the dwarf races of central Africa scarcely attain four and one half feet in height. The average weight of the male is 150 pounds and of the female 125 pounds.

Puberty. At puberty certain marked physical and psychic characters, known as the secondary sexual characters, develop which quite clearly distinguish the sexes. These changes, as experimental work on the lower animals has shown, are brought about by the internal secretions of the sex glands and can be prevented by their early removal. Also some of the sexual characters in the human female may be modified to somewhat resemble the male after the climacteric when the internal secretions of the sex glands diminish or cease. In the male the growth in weight and height is usually greater, the brain and face grow larger, the vocal cords elongate rapidly, which causes the pitch of the voice to drop an octave, the beard develops, the muscles become larger, giving a more angular appearance to the surface of the body in marked contrast to

the curves of the female, the waist is broader, the pelvis smaller, the shoulders less sloping, and the hands and feet larger.

Senescence

The normal life cycle has three phases, development, maturity, and decline. Each of the first two phases lasts about thirty years and the third should be at least of equal length. But this may be greatly exceeded as shown, for example, by the longest life yet recorded in modern times; that of Thomas Parr of England who was one hundred fifty-two years and nine months old when he died. Old age in itself is a physiological condition which results from a state of lessened vitality and activity of the various organs. The essential factor in growing old is a progressive degeneration of the tissues, as a result of changes in the cells which compose them, thereby bringing about a gradually diminishing functional capacity of the various organs until, finally, the activity of some vital organ or organs ceases and physiological death results. Certain visible external structural changes in the body are increasingly in evidence as old age comes on, all of which are due fundamentally to degenerative changes in the individual cells of the various tissues. The hair turns gray, the skin loses its elasticity and becomes wrinkled. Extensive changes occur in the jaws which are due to a loss of the teeth, with a consequent absorption of that part of the jaw which held them, resulting in a return to the infantile type of jaw. The walls of the arteries harden (arteriosclerosis) and the blood pressure increases. There is a progressive loss of strength and elasticity in the muscles. Some of the cartilages may calcify, the bones become more fragile, the cranial sutures disappear, and there is a decrease in the stature. The near point of vision recedes, due to a loss in elasticity of the mechanism of accommodation. Changes also take place in the nervous system. These are

associated with a shrinkage of the brain, due essentially to the atrophy of nerve cells in the cerebral cortex, and bring about a loss in muscular coördination and in memory, and a lack of acuteness in the senses. Normally, physical decadence occurs earlier than mental.

It is very difficult to distinguish between normal senile degenerative changes and those due to disease. For example, it seems impossible at present to tell whether the hardening of the arteries is to be considered normal or abnormal in old age. Also we know very little of the chemical alterations in the body which are associated with advancing age, except that a relative increase in the salt content has been found. In fact, the whole subject of senescence needs renewed investigation to determine what constitutes normal senile changes. The striking experiments of Steinach and others have shown, in the case of both the lower animals and man, that at least a temporary rejuvenescence can be produced in the old by engrafting the gonads or, in the male, by ligating the *vas deferens*.

There are three principal theories with regard to the biological significance of old age and natural death. The first theory is that old age is a pathological condition due to lack of internal adjustment to external environment. Metchnikoff was an advocate of this and held that there is a constant conflict between certain cells of the body, some trying to destroy the others which are essential to life. This they may accomplish if the cells acquire a lessened resistance as a result of the absorption of toxins released by certain bacteria in the intestines. Hence another species of bacteria, *Bacillus bulgaricus,* by interfering with the growth of the toxin-producing bacteria, becomes, according to Metchnikoff, a "fountain of youth." According to the second theory, which was advocated by Weismann, the higher organisms have acquired senility and natural death through natural selection as a character which

is of advantage to the existence of the species. The third theory, which was advocated by Maupas and Minot, holds that, at fertilization, a stimulus is supplied to the developing organism which is gradually dissipated, during the later growth and differentiation, until finally none is left and the organism dies of old age. As the phenomenon of old age is a common one to all metazoan animals it would seem that the third theory is more in accord with the facts.

Biologists have estimated that an animal should live from five to seven times the period of growth. This means that man should live to be from one hundred to one hundred and forty years old. The facts in regard to different animals, however, do not seem to support this view. Rubner has estimated that man requires about four times as many food calories for the period from the cessation of growth till the end of life as other mammals and he interprets this as meaning that the human cells have a much greater total capacity for obtaining energy from foodstuffs than those of other mammals. The cells seem to be able to make only a limited number of chemical transformations, after which physiological death ensues. Rubner believes that the cells in man can make a greater number of such transformations than those of most other mammals.

Vestigial Structures

The normal life cycle of man having now been considered, attention should be given to another valuable line of evidence as to man's origin, namely, certain structural features known as the vestigial organs which, although practically functionless in man at the present time, are believed to be the remains of well-developed, functional organs in the past. A few typical examples may be noted.

At the inner corner of the eye is a fold of the conjunctiva, the mucous membrane covering the front of the eyeball, called

the *plica semilunaris,* which is relatively larger during prenatal life. It is believed to be a reduced third eyelid, such as is regularly found in amphibia and birds, by which the eye is closed.

Man possesses muscles which are arranged to move the ear either as a whole or in part, but he has entirely lost the control of them or only exceptionally retains partial control. Probably when man assumed the erect posture with eyes looking forward the head became more movable and rendered unnecessary the mobility of the ear with the resulting loss of function in its muscles. At one period during prenatal development the human ear is pointed and resembles the ear of certain monkeys. This point persists in many people as a projection on the rolled or unrolled rim (helix) of the ear. It is known as Darwin's tubercle and is the vestigial remains of man's ancestral ear point.

Near the junction of the large and small intestine in man (Fig. 26) there is a narrow, blind process, about three and a half inches in length, known as the vermiform appendix. The appendix in man is a vestigial structure and represents the functionless, shriveled, terminal remains of the cæcum, the blind beginning of the large intestine. In an herbivorous animal, the cæcum is a large, nutritive organ of great importance. In carnivorous animals, the cæcum is reduced. The reduction of the terminal portion of the cæcum to form an appendix occurs only in man (Fig. 26), the anthropoid apes, and some rodents. The frequent pathological condition of the appendix in man has given rise to the aphorism "that vestigial structures are particularly prone to disease."

There are various structures in the body which, although not vestigial, give evidence of a retrogression. Such a condition is to be noted in certain of the sense organs. The olfactory organ, for example, which is of the greatest importance to the lower mammals and other classes of the vertebrates,

has become very much reduced in man and is represented only by a small part of the nasal mucous membrane. In correspondence with this the olfactory portion of the brain is also very much reduced.

Other structures showing signs of retrogression are the

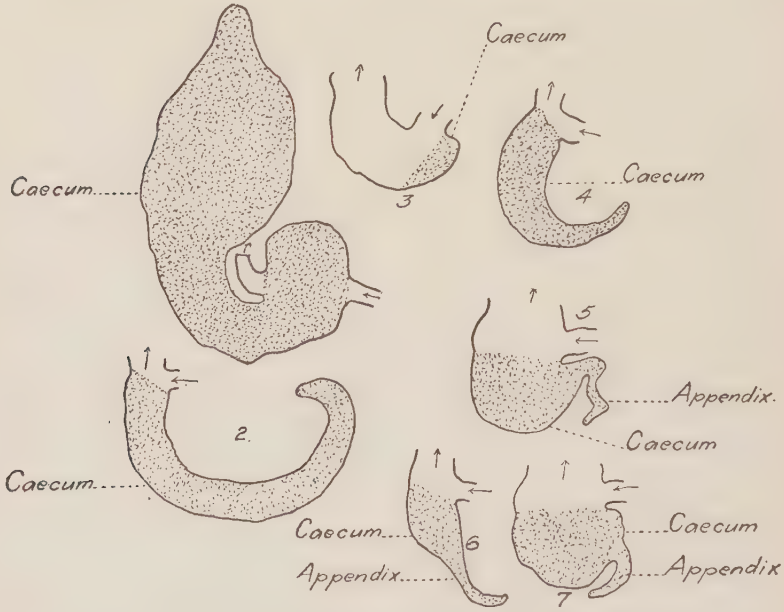

FIG. 26. THE CÆCUM AND VERMIFORM APPENDIX IN VARIOUS MAMMALS

1. Horse; 2. Kangaroo; 3. Cat; 4. Lemur; 5. Orang; 6. Man, fetal; 7. Man, adult.

Redrawn from Stratz, *Naturgeschichte des Menschen.* By permission of Ferdinand Ecke.

teeth. This is indicated by the tendency for the teeth and jaws to become smaller and is very evident when these structures in civilized man are compared with those of the primitive races and with fossil man. Additional evidence is to be noted in the occurrence of misplaced and irregular teeth which, in

general, signify that the jaw is too small. Likewise the fact that the third molars and lateral incisors are variable in development and frequently fail to appear indicates a tendency to a reduction in the number of the teeth. A comparison of man's dentition with that of a typical mammal having forty-four teeth, shows that man has probably already lost twelve teeth during his long period of evolution. The projecting chin which man alone of all animals possesses is the result of the shrinkage of the tooth-containing part of the jaw. This can be well illustrated by a comparison of the fossil jaw of the Heidelberg or Neandertal man with that of modern man. Tooth decay also is not found so extensively in the primitive races as in the civilized and is apparently absent in the fossil races, with the notable exception of the Rhodesian man recently found in the Broken Hill mine. It is clear that the usual prophylaxis against tooth decay is merely temporizing with the real problem. Since the present civilization apparently carries a distinct threat to the teeth, a radical change in diet and habits is necessary to preserve them. We are waiting for our nutrition experts to inform us as to what these changes should be.

Anatomical Variations

Finally, further evidence as to the ancestral history of man can be obtained from a study of structural variations. No two people are exactly alike in bones, muscles, or vessels, and even the nerves, the least variable structures in the body, show differences. Some of these variations are probably fortuitous, others are to be considered as a reversion to an ancestral form, and still others progressive.

Ordinarily man has twelve pairs of ribs but occasionally a thirteenth rib appears. This is known as a cervical rib and is located in the neck just above the thorax. It is generally reduced in length but may be long enough to reach the sternum.

It may be that at some time in man's ancestral history this rib regularly existed but now it occurs only occasionally as a reversion to an ancestral type. Its disappearance may perhaps be associated with the assumption of the upright gait, with the resulting dragging down of the viscera by gravity. A tendency to the loss of more ribs is seen occasionally in the partial deficiency of the first rib and in the absence of the twelfth.

Rarely a fourth molar tooth occurs in man, who regularly has only three. Some of the lower mammals have four such teeth. It is possible that the fourth molar in man, when it appears, is a reversion to the former condition. This tooth is more likely to occur in the primitive races and presumably occurred still more frequently in those prehistoric races which are known only by their fossil bones.

In about four per cent of persons a small muscle exists in the front of the thorax, parallel with the sternum, known as the *sternalis*. Anatomists have been much puzzled for an explanation of the occasional presence of this muscle. One theory is that it is part of the pectoral muscle which in some unknown way has become twisted through ninety degrees. That this may sometimes be the proper explanation is indicated by its receiving a branch of the same nerve which supplies the pectoral muscle. A second theory is that the *sternalis* is a recurrence of part of the subtegumentary muscle which moves the skin, and which is still present in many mammals but has been largely lost in man. A third explanation is as follows: in the amphibians a longitudinal muscle runs from the pelvis along the front of the entire body. Although the abdominal part of this is present in man as the *rectus* muscle, the thoracic part is absent, having been crowded out of existence, we believe, by the enlargement of the pectoral muscles following the increased use of the upper extremities for prehension. Some authorities hold that the *sternalis,* when present, is the thoracic portion of the *rectus*. An occasional nerve supply from the

intercostals favors this explanation and indicates the possible reversionary character of this muscle.

On the inner side of the lower end of the humerus in the fore limb of man there is occasionally an opening, known as the supracondylar foramen, which is regularly found in some of the lower animals, such as the cat, transmitting a large nerve. The occasional appearance of this foramen in man is believed to be a reversion.

At an early period of prenatal life a pointed projection of the vertebral column as a tail (Fig. 23) is quite evident. During later development this projection is gradually incorporated within the body so that the terminal part of the verte-

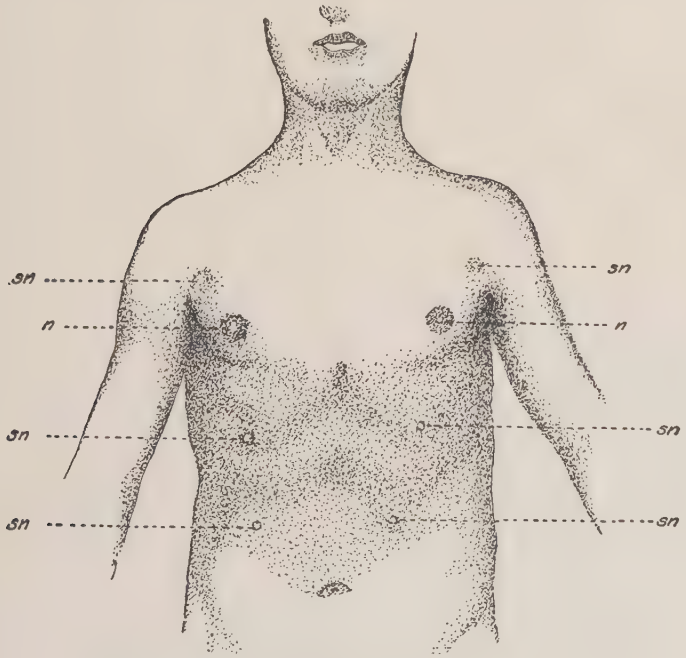

FIG. 27. SUPERNUMERARY NIPPLES OF MAN
n, normal nipple; sn, supernumerary nipple.
Redrawn from Wiedersheim, after Ammon.

bral column, the coccyx, which represents the tail vertebræ of the lower animals, no longer projects. Very rare cases are known in which the coccyx has remained elongated and projecting in man, thus constituting a true tail. In the anthropoid apes this region is even more reduced than in man.

Small supernumerary mammary glands (Fig. 27), which are not infrequently found in man, are reversionary structures. It is found that in early embryonic life, two rows of mammary glands begin to develop but, unlike the case of the lower mammals, all except two of these disappear. Also, at the sixth month of prenatal life, the body is almost entirely covered with fine hair, called the lanugo. This is largely shed before birth but, in some cases, it may persist and develop in the adult to form a complete hairy covering for the body, which seems to be a reversion to man's ancestral hairy condition such as persists in the anthropoid apes.

Thus man's close kinship with the anthropoid apes is strongly suggested not only by the fossil forms but also by his natural history. Furthermore, a 'blood relationship' is indicated both by the susceptibility of the apes to human diseases and by their reaction to various blood tests, developed in the past few years, which render it possible to distinguish between human blood and the blood of all other animals except the anthropoid apes. It is pretty well agreed that the anthropoid apes and man came from a common ancestor, and he in turn from some primitive, broad-nosed ape. Some believe that the mammals were evolved from a primitive reptilian form. Others say they came from the amphibians, which in turn evolved from a fish form, the latter from an invertebrate, and so on down to the protozoa. Evolution must likewise assume that under some favorable condition the earliest living forms were evolved from the inorganic world. Whether such a process is going on at present no one knows. However, the facts of man's development, structure, and variations, which have been given

above, certainly can be best explained on the basis of man's descent from lower forms, and human fossils, as far as they go, as is clearly shown in the previous chapter, definitely lead back toward a form from which both apes and man may have descended.

CHAPTER III

THE EVOLUTION OF THE NERVOUS SYSTEM OF MAN

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The body of man, like that of the other higher animals, carries a full complement of organs. These organs are usually arranged by anatomists under some ten heads, the so-called organ systems, and are familiar to you as the skeleton, the muscular system, the circulatory system, the nervous system, and so forth. Although physicians have been telling us that we normally live so long as our blood vessels last, it is nevertheless true that our daily life is dependent not upon a single system of organs strictly but upon the interaction of all the systems that we possess. No one system can be eliminated without serious consequences. True we may have our tonsils taken out, our appendix removed, we may lose an arm or a leg, a kidney, or even a lung, but no one will give up with impunity both kidneys, or both lungs, or shed his whole digestive tract. Death would be the inevitable and immediate result. Our systems of organs are so interrelated that they form a unified whole which justifies the biological conception of an organic individual. The integrity and continued existence of such an individual is dependent upon the presence of at least the essential members of each system. Thus the organism as a whole, to use a current expression, is more than an assemblage of parts; it is an integrated unit.

The Nervous System and Personality

Yet when we examine our systems of organs, we find them quite differently related to our daily activities; the musician trains his ear, the artist his eye, and the athlete his muscles. In this way each one develops a certain individuality or what is commonly spoken of as a personality, to use that term in its more modern connotation. In this sense personality implies an outline of the self, a *résumé* of that body of characteristics that makes up an individual in contradistinction to other individuals. Personality has commonly been regarded as an attribute of the body as a whole and yet when it is closely scrutinized, it is seen to depend chiefly, if not entirely, upon our nervous organization.

That personality has its seat in the nervous system is in the main a relatively modern view. The ancients for the most part believed that it permeated the whole human frame, and they located what may be called the attributes of personality in the most diverse parts. Thus Aristotle declared the heart to be the *sensorium commune* of the body and, though he was an unusually acute observer, he was unable to make out any nervous function whatever for the brain. Galen believed the brain to be the seat of the rational soul, but apparently he also accepted the popular belief that the heart was the seat of courage and anger, and the liver that of love. Views of this kind were the prevailing opinions among the ancient writers and show that what we regard nowadays as personality had for them a most broad and general relation to the body as a whole.

Vesalius, the great anatomist of the sixteenth century, may be regarded as the founder of the modern belief that personality is of strictly nervous origin. In dealing with the nervous system he declares that just as the heart is concerned with the vital spirit, and the liver with the natural spirit, so

is the brain with the animal spirit. By the animal spirit, as the context shows, he meant the capacity to think, to remember, to reason, and to imagine. All these functions, however, are functions of the brain, and that body of reactions, instincts, and habits that characterizes each individual whereby he may be described as honest or dishonest, cheery or somber, kindly or malevolent, are from this standpoint products of the nervous system. Although this view has been again and again assailed, it has maintained itself to the present time and bids well to remain one of the fundamental facts of biological knowledge.

Yet to the man on the street personality and all that pertains thereto remains much as in pre-Vesalian days, a vague general characteristic of the body as a whole and not a feature of one system of its organs. To attempt to persuade him otherwise is more likely to arouse his suspicions than to advance his knowledge. This is particularly true of so simple a matter as sensation. When you prick your skin with a pin nothing seems more natural than to locate the sensation of pain where the pin abraded the skin and yet we know that the sensation of pain is in the cerebral cortex of the brain and not in the skin. The evidence that this sensation is resident in the cortex comes from several sources. First, it is known that if a nerve is cut, the part of the body supplied by that nerve loses sensibility. When a nerve going to a part of the hand is accidentally severed, a pin may be thrust into that part without producing the least sensation whatever, showing that the hand in itself is not endowed with pain. Not until the restoration of the nerve months after the accident does the sensation of the afflicted part return. Not only are there circumstances under which a part may be present though without sensation, but there may be sensations without the presence of any part. This condition is well seen in the so-called phantasmal extremi-

ties. Persons who have recently lost an arm or a leg often suffer from very intense pains apparently in the missing part. So real are these sensations and so definitely do they seem to be located in the lost member that it is often difficult to persuade the patient that the pains are not connected with the lost part and that some attention to that part is needed. Yet the surgeon knows perfectly well that these sensations are caused by small tumors on the cut ends of the nerves that formerly went to the lost extremity. On removing these tumors the sensations disappear. Both these lines of evidence show that painful sensations though commonly referred to the skin are really not situated there. They are functions of a more deeply located part. When the central end of the system in the cerebral cortex suffers destruction either by disease or accident, sensation disappears absolutely and completely, a condition that shows that the real seat of this phenomenon is not in the peripheral parts of the body, as commonly assumed, but in a deep portion of the central nervous system.

This is but one example of many that go to show that personality, not only from its sensational side but from all other aspects of its nature, is a function of the nervous system. It is not a quality that penetrates the human frame as a whole. Yet notwithstanding the correctness of the modern view as to the seat of personality, the ancient idea of its diffuse nature appears in many of our daily habits and permeates our language. It would be impossible to replace successfully the heart on the February valentine by the true organ of affection, the cerebral cortex, even though the convolutions of the cortex might be shown to afford a much more subtile means of sending the hidden message than the smooth surface of the heart. Human nature clings to the past and the discarded theories of the physicians of antiquity hold their place with tenacity in the language of to-day.

The Nervous System of Man and Other Higher Animals

The nervous system of man is without doubt one of the most intricate structures in the animal kingdom. It is composed of a most complicated mechanism of end-stations and of intercommunicating lines which far outruns in intricacy the telephone system of such a place as Chicago or New York. It is made of nerve cells, or neurones, whose processes, the nerve fibers, stretch like telephone wires for relatively prodigious distances through the body. When these neurones are studied individually they are seen to fall into three classes. One of these classes is composed of elements that reach from the skin and other outlying parts, such as the organs of smell, taste, hearing, and the like, to the central organs. These neurones are called sensory or afferent neurones. Other neurones, commonly called motor or, better, efferent, stretch from the central apparatus to the muscles and other organs activated by the nerves. These form the second class. The third class, the internuncial neurones, connect one part of the central nervous system with another; they consequently lie entirely within the limits of the central organ and may be in accordance with their connections either functionally afferent or efferent. These three classes of neurones make up the whole of the real nervous substance of the human body and collectively they constitute a system by means of which many of the bodily activities are controlled and in which take place such remarkable operations as sensation, memory, volition, and the host of other performances which together constitute personality.

When we survey the organization of the nervous system and its appended parts we find that, though it is made up of neurones, the boundaries of its organs do not conform to the limits of the neurones, but have a topography of their own.

Thus a whole group of peripheral parts, often the peripheral ends of afferent neurones, are concerned with receiving such environmental changes as are likely to excite activity in the organism. Thus the eye is receptive for light, the ear for sound, the organs of touch for changes of pressure and the like. These organs, commonly designated as sense organs, but more appropriately called receptors, constitute the first large class of parts in the neuromuscular mechanism. The second class includes the central apparatus proper, composed of the central ends of the afferent neurones, the internuncial neurones, and the central ends of the efferent elements. This is the portion of the system, corresponding to a central telephone station, in which the nervous impulses arriving from the receptors are directed toward the appropriate channels of response and in which are stored those records of past experience that modify or otherwise qualify the subsequent responses. This second portion is represented in man by the brain, and the spinal cord, and by the sympathetic system and may be designated from one of its chief functions as the adjustor mechanism. Finally there is to be mentioned the third group of parts, not truly nervous themselves, but under the control of the nervous system, the muscles, the electric organs, the glands, the luminous organs and the like, all of which enable the animal to act in some particular way on the environment. These have been appropriately spoken of as effectors and complete the list of necessary parts in the neuromuscular mechanism.

A nervous system composed of the three types of neurones already mentioned and organized into receptors, adjustors, and effectors is characteristic of most of the higher animals. It is found not only in the vertebrates from man to the fishes, but also in the mollusks, in the arthropods, and in the higher worms such as the annelids. Even such a lowly organized creature as an earthworm has a nervous system developed

upon this plan. The so-called brain of this animal is a small mass of nervous material lodged in the dorsal part of its anterior end. Connected with this brain is a long segmental chain of ganglionic enlargements extending along the ventral midline of the worm. These parts collectively constitute the central nervous apparatus, or adjustor, for which the skin is the chief receptor and the muscles the main effectors. In neuronic composition the three types of elements already described are abundantly represented. Afferent neurones reach from the skin of the worm to its central organs from which efferent neurones pass out to its muscles. Internuncial neurones are also present, but in relatively small numbers as compared with the conditions found, for instance, in the vertebrates. Here many parts, like the cerebral hemispheres, to take only one example, are made exclusively of internuncial neurones whereas in the earthworm there is probably not a single important nerve center that is not entered by sensory neurones or which does not give rise directly to efferent neurones. With this difference, however, the neuromuscular mechanism of the earthworm is based on the same principles of construction as those met with in the higher vertebrates including man himself.

The Nervous Organization of Sea-Anemones

To gain some idea of the evolutionary steps by which such a nervous system as that just described has been arrived at, it is plainly necessary to examine the types of nervous organization found among the lowest of the multicellular animals. As a good example of these lowly organisms the sea-anemones may be selected. Sea-anemones are sac-like animals attached to rocks or stones, and provided with a single aperture which leads from the exterior into their large central cavity in which digestion goes on and from which the undigested residue is

discharged to the exterior through the single aperture already mentioned which serves thus both as mouth and anus. This aperture in almost all sea-anemones is surrounded by one or more circles of tentacles.

When an expanded sea-anemone is stimulated by being touched or otherwise excited to action, it commonly responds by a quick general contraction, whereby the seawater contained in its digestive cavity is discharged through its mouth and the whole volume of the animal is greatly reduced. This general contraction may be called forth from almost any point on the surface of the animal, showing that the muscles that lie within the walls of the creature and are responsible for the contraction, are collectively accessible to nervous impulses from almost every point on the surface. This accessibility is insured through the presence of a nerve-net which spreads throughout the living substance of the animal and which brings its surface into connection with almost its whole musculature. This nerve-net nowhere shows a special concentration but extends rather uniformly throughout the body and thus affords an easy path over which impulses may spread from the surface of the animal to its musculature. A nervous system of this type is commonly called a diffuse nervous system as contrasted with a centralized one and is characterized by the absence of a central organ, or adjustor, through which all impulses must pass on their way from the receptors to the effectors.

The characteristics by which a diffuse nervous system may be distinguished from a centralized one are well shown in a number of activities exhibited by sea-anemones. When small fragments of meat or other bits of food are placed on the tentacles of a sea-anemone, these organs wind around the bits of food and, by bending in the appropriate direction, deliver them to the mouth. If, now, a distending tentacle on a quiet and expanded sea-anemone is suddenly seized at its base by forceps, cut off and held in position so that its original rela-

tions to the animal as a whole can be kept clearly in mind, the tentacle will still be found to respond to food brought in contact with it and will eventually turn toward that side which was originally toward the mouth. Thus the tentacle has within itself a complete neuromuscular mechanism for its own responses and it is unnecessary that it should be connected with any general nervous center in order to carry out its characteristic movements. Its share of the diffuse nervous system is sufficient for its own needs. How different this type of organization is as compared with the centralized type is seen when we contrast the activity of the tentacle with that of the leg of a dog or the claw of a lobster when severed from the animal's body. These parts when thus cut off are quite incapable of coördinated movement and show no evidence whatever of the type of response that characterizes them as a part of the whole organism.

Another activity of the sea-anemone that illustrates the nature of the diffuse nervous system is creeping. This operation is accomplished by the so-called pedal disc, that portion of the animal by which it attaches itself to the substrate. By means of muscular waves that pass across this disc the sea-anemone may creep slowly like a snail from spot to spot. If a sea-anemone is cut crosswise in two and the upper half of the animal carrying the mouth and tentacles is thus removed, the lower half with the pedal disc intact will pucker up the wounded surface and soon creep about with as much success as the whole animal did. Here again the part concerned carries within its own bounds a neuromuscular mechanism complete for its needs.

Again if a sea-anemone is fed from one side of its mouth, it will take in by means of the tentacles on that side one fragment of food after another. If, now, bits of meat be alternated with bits of filter paper soaked in meat juice, the two materials will be accepted indiscriminately for some eight or

ten trials after which only the meat will be taken and the filter paper will be discharged into the seawater without being brought to the mouth. If, after having developed this state of affairs on one side of the mouth, the experiment is now transferred to the opposite side, both the filter paper and the meat will again be taken in till this side has also been brought to a state of discriminating. Thus the experience of one part of the animal has no perceptible influence on another in the sense that there is no common nervous center where the experience of a given part may be put to the service of the rest. It is as though we had to burn each finger in turn before we discover that fire is bad for the hand. These examples bring into strong contrast the types of reaction characteristic of the higher and the lower multicellular animals and serve to illustrate the difference between the centralized and the diffuse nervous system.

In a diffuse nervous system, such as that possessed by a sea-anemone, the external surfaces of the animal serve as receptors and these communicate directly with the subjacent musculature. The nerve-net serves to spread the impulses throughout the body but without involving any central organ. Thus the sea-anemone may be said to possess receptors and effectors without an adjustor or central nervous organ properly so called. This central organ is, therefore, a feature of the higher animals and in comparison with receptors and effectors it must be looked upon as a more recent evolutionary acquisition. Our sense organs did not develop in consequence of a central nervous system but our central nervous organs developed because our very early ancestors had already acquired receptors and muscles.

If lowly organized animals, such as sea-anemones, possess nothing worthy of the name of a central nervous organ, it follows that their so-called sense organs must differ considerably in function from those of the higher animals. In highly

differentiated types the sense organs, the eye, the ear, the organs of touch, of taste, and of smell, are concerned with supplying the central apparatus with those elements out of which the intellectual life is built. This function must be entirely superfluous in such an animal as a sea-anemone where no central organ exists. Here the sense organs are not concerned with sensations; they merely excite muscles to action, a function which they also exercise in the higher animals. They are receptors for a multitude of external changes and when thus excited they serve as triggers, so to speak, to set off the subjacent muscles. Since they are not concerned with sensations they are more appropriately designated as receptors than as sense organs and hence the term receptor, which is the more inclusive of the two, is the better one to employ. Sea-anemones, therefore, represent a more primitive type of neuro-muscular mechanism than the higher animals do, one in which of the three organs, receptor, adjustor, and effector, only the first and last are present, the adjustor, or central organ, being a later acquisition.

Sponges

If receptors and effectors were developed before adjustors, it is natural to ask whether of these two parts one preceded the other or did they both evolve simultaneously? Among the multicellular animals lower than the sea-anemones, the sponges throw light on this question. A single sponge is a goblet-shaped or finger-shaped animal attached to the sea-bed. Its outer surface is covered with pores which lead into a system of canals provided with lash-cells by which the water is moved through the canals to a large space in the middle of the sponge from which this fluid escapes by a conspicuous opening at the unattached end. From the current of water thus passing through the sponge the animal extracts its nourishment and the

production and control of this current is one of its essential activities.

Many sponges, like the ordinary bath sponge, are colonial animals and consist of a number of sponge individuals more or less fused together. In the bath sponge, which in its commercial form is represented merely by its horny skeleton, the number of individuals can be judged by the number of very large openings that penetrate from the outside to its interior. These are usually four, five, or more in number and represent the outlets for the water currents in the living sponge. In quite a number of the colonial sponges the component individuals are much more separated than in the bath sponge and rise from a common base as so many separate fingers. Such fingered sponges are very convenient for study and are commonly of such a size as to admit of easy experimental treatment.

Sponges are for the most part extremely inert and aside from a slight contraction and consequent bending of the body as a whole they show very few activities except the opening and closing of their pores and other apertures. In this way sponges control their water currents and they accomplish this partly by the formation of protoplasmic membranes by which the pores are closed and partly by the action of rings of simple muscle cells that surround the pores, especially the outlet openings.

The control of a given outlet cannot be accomplished from an adjacent finger nor can it be brought about by stimulating the finger at the end of which the outlet lies except when the stimulus is directed to the immediate neighborhood of the outlet itself. In fact there is not only no experimental evidence to show that one finger is connected nervously with another, but there is no reason to suppose that parts of the same finger are thus connected. In other words, nervous

transmission, such as is abundantly seen in sea-anemones, seems to be completely absent from sponges. When this fact is coupled with the inability of histologists to discover any trace of nervous tissue in sponges, it seems safe to conclude that these animals are devoid of nervous elements and that their muscles are set in operation by direct stimulation rather than by anything that may be described as a nervous impulse. From this standpoint, therefore, sponges may be regarded as animals provided with muscles but devoid of nervous tissue. They possess effectors but no receptors and their condition suggests that in the evolution of the neuromuscular mechanism, muscle appeared first and nervous tissue later, developing probably in close proximity to the previously formed muscle as a device for exciting the muscle to action.

If this conclusion is true, the evolution of the neuromuscular system must have begun with the appearance of muscle as an independent effector, after which receptors, or nervous elements to serve as triggers for setting off the muscles, were added. Finally, between the receptors and the effectors a central nervous organ, or adjustor, grew up as the third element and thus completed the neuromuscular system as exemplified in the higher animals. So important has this central organ become in the life of these animals that we scarcely realize that it is the latest addition to our nervous equipment and yet such seems to be the case. In its first appearance it must have been chiefly an organ of transmission and intercommunication, a specialized outgrowth of the more diffuse nerve-net. Later it doubtless took on the function of modifying the animal's responses in relation to its past and thus became a storehouse of experience and the seat of the intellectual life. As such it has reached its highest point of development in the vertebrates where as the brain of man it is without doubt the most remarkable structure ever evolved.

The Nervous System in Vertebrates

The central nervous organ of the vertebrate, using this term in the most limited sense, consists of the spinal cord and the brain. The spinal cord throughout the vertebrate series is a relatively uniform structure, but the brain exhibits a strikingly progressive development. This is seen especially in two of its parts, the cerebellum and the cerebral hemispheres. Both, but particularly the cerebral hemispheres, grow immensely in size and complication as we proceed from the fishes to man. In the lower vertebrates the cerebral hemispheres are concerned almost entirely with the sense of smell and their cortex, or outer covering, is spoken of as the olfactory cortex, or archipallium. In the mammals, however, the hemispheres have reflected upon them, in addition to olfaction, practically all the sensory activities of the body as well as the mechanism for the voluntary control of the musculature. These added parts constitute the neopallium which shoves the olfactory archipallium into the background. Thus the neopallium comes to be the great central organ of the higher animals. It receives almost the whole of the sensory inflow; it stores the impressions of the past; and from it emanate those impulses that excite what we call our volitions.

It is a remarkable fact that in man the cerebral cortex consists of layers of nerve cells so regularly arranged that a rough estimate of their number may be made. This is believed to be approximately 9,200,000,000. This prodigious number of cells is estimated to weigh a little over thirteen grams and to occupy the space of less than a cubic inch. When it is remembered that every human being develops from an egg cell of approximately one fifth of a millimeter in diameter and that this cell begins growth by dividing into two, and these two each into two thus making four, and then into eight, sixteen, thirty-two, and so forth, it will be seen what a stupendous process

development is even from the standpoint of simple numbers, for from this one egg cell by division must come not simply the nine billion and more cells of the cortex, but all the other countless billions of cells that go to make up the rest of the body. Nor is this process of cell multiplication, prodigious as its results show it to be, the only remarkable feature in development, for it is also equally striking that when the requisite number of cells have been produced, the operation of cell division stops. At least this is true of the cortex, for here, as in a few other parts of the body, the neurones change very little in number after birth. The brain cells with which the babe is born last for the most part without renewal through mature life to old age and death. What brings the operation of cell multiplication to an end at the appropriate moment is as little understood by embryologists as is the exciting cause of the initial increase.

When it is recalled that the 9,200,000,000 cells in the human cerebral cortex are the nervous elements of this organ and that they collectively constitute rather less than a cubic inch of protoplasm, it seems almost incredible that they should serve us as they do. They are the materials whose activities represent all human mental states, sensations, memories, volitions, emotions, affections, the highest flights of poetry, the most profound thoughts of philosophy, the most far-reaching theories of science, and, when their action goes astray, the ravings of insanity. It is this small amount of protoplasm in each of us that our whole educational system is concerned with training and that serves us through a lifetime in the growth of personality.

The Nervous System and Sex

The great importance of the nervous system for all that pertains to the higher life of man cannot be denied and yet this

system after all is only one of our numerous systems of organs and lies embedded with the rest as part and parcel of our bodies. Notwithstanding its unique character, the nervous system is profoundly influenced by its organic environment and reflects in much that comes from it the characteristics of the body in which it lies. This is nowhere more clearly seen than in the effects which hormones have upon it. Hormones, as you already know, are substances produced in the bodies of the higher animals by the ductless glands, or endocrine organs as they are now called, and circulated by the blood. They are powerful activators for many bodily reactions and are of first importance in many organic activities. Certain hormones have a profound effect upon the nervous system and consequently upon personality. In this respect they are like the supposed humors of the physicians of antiquity. These humors were believed to be four in number, blood, phlegm, yellow bile, and black bile, and an excess of any one of these gave a corresponding temperament, sanguinary, phlegmatic, choleric, or melancholic as the case might be. This idea of the humors is really a forerunner of the well-established theory of the hormones, which, however, not only has to do with temperament but with many other functions of the body. That materials introduced into the circulation have a profound influence on our moods and other mental states is well known and is the basis of the use and abuse of many substances, such as narcotics, alcohol, coffee, tea, tobacco, and so forth. It is, however, only within the last few years that the immense importance of hormones in relation to the nervous system has begun to be seen. The hormones concerned are those that have to do with the sexual traits.

The great majority of animals are either male or female and when we seek for a definition of these states we are driven in the end to make it turn upon the kind of reproductive cells that the individual produces. Males produce sperm cells;

females egg cells. These are the primary sexual characteristics. But the sex of the great majority of higher animals can also be determined by many features other than those of the kind of reproductive cell discharged. Thus in man the male as compared with the female is usually larger in stature and more robust, has hair upon the face, a deeper voice, and many other features all of which go to mark the sex as clearly and as indubitably as the primary sexual character itself. These more superficial and obvious distinctions are spoken of collectively as the secondary sexual characters and serve, as has just been intimated, with almost perfect certainty as an indication of sex. If, however, there is any ambiguity in this respect, the final resort in a decision is always to the primary sexual characters, the kind of reproductive cells produced by the given individual.

For a long time much interest has been expressed as to the way in which the secondary sexual characters arise and it is from this standpoint that hormones have come into much prominence. Very remarkable experiments in this direction have been recently carried out by Steinach on guinea pigs and rats. The original object of this line of work was to ascertain the influence of the sexual glands on the secondary sexual characters, but the outcome of it was the discovery of a means of influencing in a most profound way the sexual life of an individual, in fact, so far as secondary sexual characters are concerned, of converting a male into a female and vice versa.

Steinach removed the male reproductive glands, the testes, from young guinea pigs and, after they had recovered from this operation, he implanted in their bodies by means of a second operation the female gland or ovary from a young female. The animal destined by nature to be a male but thus harboring within its body the opposite sex gland was allowed to mature, whereat a most remarkable transformation was observed. It developed the bodily proportions of the female in skeleton, hair coat, and other particulars, its mammary

glands enlarged and even gave milk, but what is perhaps more remarkable was that its whole nervous constitution gradually assumed the female rôle. It became rather timid and retreating, mothered the young of other females and in practically all respects exhibited the traits of the female of its kind. Organically it displayed practically the full range of secondary female characteristics though it was an animal destined by nature to have been a male.

Steinach also undertook the conversion of females into males and though this from the operative standpoint proved to be a more difficult problem, in that testes had to be repeatedly introduced, he nevertheless also succeeded in this endeavor and individuals were produced that though destined by nature to be female had the physical and psychical traits of males. Such individuals were aggressive and quarrelsome, and attempted, though ineffectually of course, to copulate with females.

Thus the presence of a particular sex gland during adolescence seems to be the necessary factor in determining the type of secondary sexual characters that a given individual will show. When the sex glands that had been transplanted in these experiments and that had sojourned in their new habitation for a considerable time were studied histologically, they were found to be considerably modified. The sexual cells proper had often largely disappeared and the cells that filled the spaces between the groups of sex cells, the so-called interstitial cells, had often greatly increased. It is these cells rather than the sex cells which produce the hormones that determine the secondary sexual characters, and the sex glands must, therefore, be looked upon as double in nature. They produce, first, the sexual elements, the sperm cells or the egg cells, and secondly, from another source, the hormones necessary for the development of the secondary sexual characters. They are at once sex glands and puberty glands.

When the full import of these experiments is clearly recognized, it must be admitted at once that the sex glands not only control such secondary sexual characteristics as are of a physical nature, such as bodily proportions and the like, but also those more subtile features, the reactions, responses, and instincts, which are equally significant in defining a given sex. These features collectively have their origin in the nervous system and since they are now known, from the experiments of Steinach, to depend for their development upon the sex glands, it follows that the nervous system of an immature animal must be looked upon as neither male nor female but indifferent and yet capable of developing in either one or the other direction in accordance with its organic environment.

That the conclusions to be drawn from Steinach's experiment apply with full force to human beings is now commonly admitted. The striking influence of the sex glands on personality as well as on the more physical aspects of the individual is well known to every surgeon and is a cardinal point in his practice. Yet the relation of this simple fact to human society often goes unheeded. Few elements lie deeper in the nature of man than sex. As the center around which the family is built up, it initiates the first step in the structure of society. From this soil have sprung the affections, chivalry, the poetry of love, and all that vast array of literary and artistic accomplishment that has as its theme man and woman. And yet when the physical background of this immense pageant is sought for, it appears to depend upon the action of the interstitial secretions of the sex glands on plastic nervous organs. It is this plasticity that is both novel and important, for it may have far-reaching consequences in the reconstruction of society. Through it personality may be profoundly affected, abnormal states may be reached and corrected, and fundamental regenerations accomplished. As an avenue of entrance it leads to a most important field for the psychiatrist and the social

reformer. Thus the hormones, to return to our original thesis, illustrate how profoundly the nervous system is under the influence of its immediate organic environment.

The Nervous System and Organization

If, now, we picture to ourselves the evolution of the nervous system of man, we must imagine the formation of the chemical elements from the electrons of the stellar laboratories, the combination of certain of these elements into organic aggregates and the formation of unicellular organisms, the development of multicellular types in whose organization muscles appear, then receptors, and finally adjustors or central nervous organs culminating in the brain of man.

Such a series forms, superficially, a seemingly natural and smooth sequence and yet when it is examined closely, it proves to be a succession of breaks and contradictions. The carbon, hydrogen, oxygen, nitrogen, and other elements of our bodies act in a radically different way in the hands of the chemist from what they do as an organized part of our nervous protoplasm. The invariable nature of the chemical reaction is in strong contrast with the fluctuating uncertainty of volitional activity. True, on repeating what are intended to be exactly the same processes, the chemist never gets exactly the same results, but he knows that the slight differences he meets with in his work are errors of manipulation and observation and not evidences of wilfulness or disobedience on the part of the material he deals with. Yet the activities of these same chemical elements when organized into the children of his family are regarded in a very different light and under the head of personality he subjects them to censure and approval with the view of lasting change and improvement. How profoundly different is the conception of the activities of the isolated elements of our bodies and of these same elements organized into

parts of ourselves! No one now entertains seriously the view once put forward by Haeckel in the heyday of the evolutionary movement that since human beings have souls every atom of their bodies must have part of such a soul. The circumscribed nature of ordinary chemical action and the freedom of human volition, notwithstanding its elemental background, are two different things.

If the peculiarities of volitional action are not to be discovered in the chemical elements that make up the substance in which it occurs, they must be ascribed to the organization of this substance, that is, to the way in which the elements of this substance are put together and interact amongst themselves. From this standpoint certain chemical elements organized as nervous protoplasm have a greater degree of freedom in their action than when the same elements are organized in the form of lifeless molecules. This condition may be illustrated by a simple mathematical relation. The ordinary and invariable type of chemical reaction might be likened to what would take place in a mathematical world made of blocks of fives to which we put the question, What constitutes ten? To this there is only one answer, namely, two blocks of five. The type of reaction that is possible in nervous protoplasm is like that in a world made of the digits to which the answers as to what make ten may be nine and one, or three and seven, or any other of numerous combinations all equally true. This world has in it a degree of freedom comparable to that in nervous protoplasm as compared with the limitations of the ordinary chemical reaction. From this standpoint, then, nervous protoplasm, and probably most other protoplasm, when considered from the point of view of its chemical activities has a greater degree of freedom than that seen in the ordinary chemical reaction and in this characteristic is to be found the possibility of all volitional performance. That the properties and activities of materials change with changes in organization

is as well known to the student of the lifeless phases of nature as to those who concern themselves with the so-called organisms. The qualities and activities of water are no more novel or different from those of its component elements, hydrogen and oxygen, than are the qualities and activities of nervous protoplasm as compared with the organic molecules that make it up. Water is organized hydrogen and oxygen and in consequence of its peculiar type of organization it exhibits properties quite unlike those of its constituent elements. Thus water, like protoplasm, differs from its elements in consequence of its organization.

It is sometimes assumed that man is absolutely untrammeled and free and that his inner life is without restriction, but such is not the case. A good example of how we are held in abeyance is seen in our mental furniture. This consists of elements, our sensations, that reach us from the outer world through our sense organs. These elements come to us from the environment and from nowhere else. We never invent them nor in any other way develop them within ourselves. The mind is strictly limited to what in this respect is supplied it from its exterior. What may be done by way of freedom and originality is to set these elements in novel and unusual combinations and it is in this way that the highly imaginative and perhaps the insane mind works. But in all instances the elements themselves are those of the primitive sensations and to such we appear to be absolutely limited.

Not only is the mind thus limited in its materials, but its processes often show striking restrictions. This is illustrated by the magician's receipt for turning stone into gold. Put a clean stone into a pot of boiling water and watch it ten minutes during which time, if you do not once think "hippopotamus," the stone will turn into gold. Needless to say that no one by this means has ever enriched himself. The mind of man even in working toward its desires is never absolutely free, but is

subject to restrictions which continually recall the material background on which it rests.

In the evolution of the nervous system of man as presented in this brief outline we see a succession of steps rather than a gradual ascent and at each step a fundamental change suddenly appears, mutation-like in its character, to borrow a term from the geneticists. Each step is a new phase in organization, but not necessarily a change in the kind of elementary materials involved, and with these changes in organization come changes in the degrees of freedom of reaction which enable us to bridge over the gulf that lies between the relatively circumscribed activity in ordinary chemical operations and the greater freedom seen in the voluntary and responsible acts of human beings. Something of this view of the nature and the possibilities of living protoplasm has been put forward by Haldane under the name of organicism, but with perhaps less reliance on the material side of the problem than has been suggested in this lecture. Yet interesting and important as it is to push, to the extreme, speculation as to the relation of our mental life to the materials of our body, it nevertheless must be remembered that, with all our progress, we are still not far from the position described by Vesalius in 1543 when he wrote, "How the brain performs its functions in imagination, in reasoning, in thinking, and in memory, I can form no opinion whatever."

CHAPTER IV

THE EVOLUTION OF INTELLIGENCE

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It may be assumed without argument that evolution has actually occurred within the field of intelligence, as it has within the field of organic structure, and I shall proceed at once to examine the major features of the process. It will be convenient to distinguish in such an analysis between the development of intelligence in animals and the corresponding development in man. This distinction is not for a moment intended to postulate any fundamental difference between human and animal intelligence, for this is one of the questions which can only be confidently answered, if at all, after adequate examination of the available data. It is simply a device for expediting access to two great groups of facts which present certain practical distinctions.

In the field of cosmic and stellar evolution, we have such facts as are disclosed to us through telescopic and spectroscopic examination of the heavenly bodies, with their convincing indications of evolutionary processes extending over unimaginable epochs of time and over equally abysmal areas of space. In the case of the crust of our own earth, geology similarly brings to our knowledge evidence of slow, age-long changes, as a result of which the present superficial characteristics of the earth's surface have been produced, together with its climatic and other peculiarities. Again, there is convincing

evidence of change and development, of rise and fall, in the tide of animal life, in its geographical range, in its anatomical organization, and in its adjustability to the major features of environment. One of the lectures in this series has in particular been devoted to evidence of this character as it applies to the changes brought about in the nervous system of various forms of animal life. The development of man himself and of the society within which he lives has also been passed in review and convincing demonstration has been offered of the extensive changes which have, throughout the ages, come to pass in both. Evolution having been thus convincingly exhibited in a number of important fields, it behooves us, in discussing the present problem, to secure impressions as clear as possible of the character of the evidence upon which we are to base our inferences and conclusions regarding the development of intelligence.

Animal Intelligence

In the case of animal life, the only available information is to be gained by the direct observation of animal behavior as that is found among the creatures surviving in our age of the world. Whether there may have been creatures in the past possessing forms of intelligence substantially different from that of any animals now living can neither be denied nor asserted with absolute confidence. But such evidence as we have is at least all against the inference that animals superior to those now living have ever been developed. So great is the similarity of existing forms to such extinct forms as are known to us, that it seems highly improbable there should have occurred developments of intelligence widely different from those represented in the animal life of to-day. This inference, to be sure, rests upon the hypothesis which most scientists regard as conclusively established, to wit, that intelligence is

essentially a function of the nervous system and that its characteristics vary with the development of the latter.

Turning, therefore, for our clew to the behavior of living organisms, we find this ranging all the way from the very simple series of movements executed by the unicellular organisms like amœba, which is quite devoid of a specialized nervous system, up to the complicated behavior of the primates and the phenomenal intellectual achievements of man himself. At once we are confronted with a distinction which, much transformed in modern times, goes back to the period of the earliest speculations upon mind and behavior. All the early writers known to us stress the distinction between instinct and reason, accrediting to the animals instinctive behavior of a far more highly developed type than that disclosed in the behavior of man, and assigning to man powers of reasoning either wholly or largely denied to animals. Modern scientific analysis has been disposed greatly to qualify the rigidity of this distinction. Man certainly has a very definite equipment of instincts and some of the operations of animals contain in them the beginnings at least of rational conduct.

Broadly speaking, actions are designated intelligent when they disclose the ability to adjust quickly and successfully to new and variable conditions. They are judged unintelligent or mechanical when the same action is elicited again and again regardless of changes in the situation which calls it forth, or of the possibly disastrous nature of the reaction itself. From this point of view, the great group of actions, known as tropisms, must be regarded as non-intelligent, even though they may at times benefit their possessors. Here, for example, is a group of organisms which at once seek the darkest corner of any area within which they are confined. Here is another group which seeks the lightest place. Again, here is a group which, if possible, takes up a position where the body may press, or be pressed upon by, surrounding objects. In the case

of such organisms these tropistic tendencies are ordinarily responded to no matter how untoward the consequences. The moth seeking the flame is a common exemplar of this kind of reaction. And the biologically undesirable consequences are plainly exhibited in the demise of the performer.

The group of reactions called reflex exhibit a similar organic invariability which, while generally beneficial, is not infrequently disadvantageous. In the human being sneezing, coughing, weeping, are familiar examples of actions of this character. They are largely outside the range of voluntary control and the more extreme forms, such as those of digestion, are completely independent of such control.

Instincts shade off into reflex and tropistic reactions by gradations, which makes it difficult without being arbitrary to draw any hard and fast lines; but they are in the higher organisms much less rigid and fixed than the tropisms and reflexes and they are more complicated than the latter because they involve a series of muscular movements, instead of the single movement to which we apply the term reflex.

All this group of activities, however, have in common their hereditary and innate character. No one of the group is ever in any proper sense learned or acquired. They are executed either at birth, or at some later stage of the creature's development, with a high degree of perfection and in the lower animals they are generally quite rigid and devoid of any suggestion of intelligent adaptation. They certainly represent hereditary pathways through the nervous system over which stimulations travel to the muscles and glands. In the higher animals, the instincts are more or less plastic and susceptible of modification, this modification in some cases going so far as to result in the complete suppression of the instinct by unfavorable environmental conditions. Most of the instincts have a reasonably obvious biological utility, in that they contribute to the maintenance of the life of the individual or the

species, and the same thing is true of the reflexes and, presumably, of the tropisms.

Among the various theories of the origin of this group of instinctive and reflex actions, two have been most frequently urged. The one derives its chief support from an examination of the supposed facts in the case of human beings. It assumes that the expression of life in its original forms was spontaneous and indefinitely variable. It further assumes that something comparable with volition is present in these primitive spontaneous expressions and that this volition is intrinsically intelligent, so that among the various spontaneous, or random, forms of movement which may be indulged there is presently a selection of those which are most useful and a suppression or elimination of those which are harmful. Whereupon it is further assumed that these beneficial spontaneous reactions become embedded as fixed habits which presently are transmitted by heredity to succeeding generations. They constitute on this theory a sort of frozen intelligence. Although this view has been held in times past by scientific men of eminence, it is certainly not looked upon with favor by any considerable number of contemporary scientists. It makes assumptions about inheritance which are almost certainly incorrect and assumptions about primitive intelligence which are highly improbable. Over against it is the view that, behavior being essentially a function of structure, reflexes, instincts, and tropisms simply represent accidental variations which have survived, just as the variations of form have survived, because they were, on the one hand, positively useful, or, on the other hand, sufficiently harmless to permit their continuation, if only they chanced to be combined with other reactions of a preservative kind. Both theories admit that, as things now stand, acts of reflex and instinctive character, whatever their evolutionary history, are as such intrinsically non-intelligent,

non-adaptive to variation in environment. This is as true of man as of animals.

Again broadly speaking, it must be recognized that the range and complexity of animal instincts bears some relation to the organization of the central nervous system, but the relation is a highly complicated one. Certain arthropods, for example, like the ant, the bee, the spider, the wasp, have amazingly elaborate instincts, although the pattern of the nervous system is relatively simple. On the other hand, certain of the mammals whose nervous system simulates that of man himself are equipped with instincts of a seemingly less complicated and remarkable character. Unequivocal tropisms, as might be expected, are generally more striking and presumably more frequent in creatures of simpler type than in those higher up the scale. As is natural, instincts tend to follow patterns appropriate to the particular environment in which the animal thrives. Birds thus develop nesting instincts, which are quite different in form from any correlative instincts of fishes. The latter, on the other hand, develop spawning instincts, which vary in some essential particulars from the reproductive instincts of the birds and mammals. In discussing intelligence it is highly essential to keep constantly in mind these inherited forms of behavior and to distinguish them sharply from acts acquired by the creature of its own initiative.

With this brief background of general impressions regarding instinctive and reflex endowment of animals, we may turn attention to their more strictly intelligent behavior. At this point we are thrown back on two types of evidence whose relative value is estimated quite differently by different scientists. We have, on the one hand, the observations of the outdoor naturalist, who undertakes to describe the behavior of animals as seen under the typical conditions of nature. On the other hand, we have the experimental school, which has attempted to study and analyze the behavior of animals under

laboratory conditions of control, or at least under conditions of a somewhat artificial character. Evidence of the first type tends to be anecdotal in character and, in the nature of the case, is rarely able to present any trustworthy account of the life history of the individual creature whose behavior is under discussion, or indeed of the immediate antecedents of the particular episode under consideration. It would be at once unjust and ungracious to deny substantial value to much of the information emanating from such sources. Indeed, with the case of the instincts nearly all of our knowledge derives from this source. But on the other hand, evidence of this character may be subjected to the most searching scrutiny, for to it attaches not only more than the usual dangers of inaccurate observation, but also the all but inevitable tendency to anthropomorphic interpretation. This is the happy hunting ground of the nature faker and of the manufacturers of Arabian Nights tales and Baron Münchhausen legends of animal life and behavior. None but a hopeless ingrate could recall Mowgli and his friends without a sentiment of deep and lasting gratitude; but, if taken as more than literary romance, the accounts of Kaa, of Shere Khan and the Banderlog, to mention no other instances, can only result in profound misapprehension.

On the other hand, the laboratory school suffers from the charge of subjecting animals to abnormal conditions, under which their reactions are distorted and in which it is impossible to expect normal expressions of their intrinsic intelligence. As regards the larger undomesticated animals, there is doubtless some force in this type of criticism, and indeed when it comes to certain forms of procedure, to be mentioned in an instant, it may be alleged with some show of proof, that the very conditions under which the observations are made tend to defeat their own purposes. For example, it is a not uncommon procedure in animal experimentation to create in-

centives to the solution of simple problems, either by creating strong hunger, or by the use of somewhat severe punishment. In either case, it is alleged that the animal is thrown into an abnormal emotional condition highly prejudicial to the exercise of such powers of intelligence as it may possess. Objections of this character are all appreciably less significant when urged against the milder and less unnatural forms of experimental procedure employed, let us say, in the case of simple marine animals, to whom can be given, under laboratory conditions, surroundings so closely simulating their native habitat as presumably to rob them of any real abnormality. Moreover, after every criticism has been recorded, it still remains true that, when affirmative evidence of intelligent behavior is secured under conditions of experimental control, whether inside or outside a laboratory, the validity of such evidence is likely to be forever exempt from the uncertainty which almost inevitably attaches to the incidental observations of animals in nature.

It is necessary to direct attention to these two main lines of attack upon animal intelligence, for the reason that observations which have been reported from these two sources have often varied fundamentally. The works of the outdoor naturalist, for example, are full of records of animal behavior alleged to afford the most unequivocal evidence of reasoning processes approximating those of man himself, whereas the experimentalists have generally failed to discern anything of this kind and in its place have reported literally thousands of instances of behavior wholly devoid of the characteristic features of human thinking.

It will be readily understood that no observation of animal behavior is likely to be trustworthy, unless based upon a wide and exact knowledge of the animal's usual habits of life. Otherwise one is exposed to the error of interpreting as a

rational process a piece of behavior which may be partly or wholly instinctive, or which may have been acquired by wholly unknown means at some earlier period of the animal's life.

When due allowance is made for such modifications as have been already suggested, the general upshot of the observations of the experimentalist may perhaps be summarized in this way. The very simple forms, like the low marine orders, exhibit a relatively limited group of reactions, some of them tropistic in character, others, however, seemingly somewhat variable, but few of them suggesting any exercise of intelligent discrimination. A little further up the scale, animal forms are encountered which are equipped with fairly definite instincts and which evince the ability to learn to accommodate themselves to changes of environment, but only by the slowest and most tedious processes, giving practically no indication of any trait which one would naturally designate intelligent. Thus the frog, for example, by earlier observers supposed to be entirely incapable of taking on any modified reactions by the process of learning, has now, through the most patient observations, been found to be capable, after many, many trials, of slightly improving his reactions. Granted, for example, two pathways, one of which always leads to food and the other not, he can, if the patience of the experimenter is sufficient, ultimately learn to choose the correct pathway. Still further up the scale, as will be illustrated in some of the lower mammalian forms, we get more positive evidence of the beginnings of real memory and of a more definite ability to modify reactions in a beneficial manner, although this capacity with some of the mammals, such as the guinea pig, is almost at the zero point. With others, however, and particularly with the primates, there is much greater adaptability, and in a few seemingly well-authenticated instances there is evidence for something at least suggesting the human forms of inference

and thinking. This amounts to saying that there is in the animal kingdom, as we know it, the widest range of behavior extending from that which at one end of the line is almost, if not wholly, stereotyped and mechanical to forms which at the other extreme represent not only a rich life of plastic instinct, but also highly variable forms of behavior, some of which definitely suggest the possession of rudimentary intelligent powers. There is, then, conclusive evidence of a real evolutionary process, if one assume, as all scientists now do, that the more complex organisms, in which behavior is most elaborate and intelligent, have arisen from simpler and historically antecedent forms. That is to say, there is no question whatever regarding the wide variety of the present modes of behavior extending from the reflex and tropistic type up to the variable intelligent type, and, on the basis of the evolutionary conception of organic structures, there can be no question that these differences in behavior represent historic evolution of the more complex out of the simpler.

Intelligence and Consciousness

This is perhaps a convenient point at which to mention an issue often much magnified in discussions of mental evolution, to wit: Are all animals conscious, or is consciousness a phenomenon which appears only at a certain stage of evolutionary development?

Disregarding earlier historic theories, there have been three distinct positions represented by contemporary scientific opinion. One of these holds that all animals are conscious, even an amœba. Indeed, the defenders of this extreme view have sometimes gone further in maintaining not only that all life, plant as well as animal, enjoys at least a rudimentary form of consciousness, but also that the whole physical universe is but one aspect of a reality, which seen in its entirety presents

a corresponding conscious phase. Needless to say, we must eschew for present purposes any discussion of this larger issue.

There is, second, the view that consciousness appears in the evolution of the nervous system at that point at which there is demonstrable evidence that creatures can learn to improve their reactions on the basis of experience. From this point of view, the frog, among the more familiar of our animals, would represent perhaps the stage at which the first gleams of intelligence are discernible. Practically, this test is a very difficult one to apply, because it would be precarious to allege with confidence that, granted sufficient repetitions of a given situation, any animals would fail to show some modification in response. But purely physical and chemical reactions, for example the formation of crystals in minerals, exhibit a similar slow modification. And yet, in this case, one would hardly be disposed to allege the presence of consciousness. Furthermore, where animals low in the scale apparently display adaptive reactions, it is difficult to be certain that the chemical and physical stimuli affecting them are all under control, so that the seeming adaptation may be accepted as bona fide.

A third view holds that no animals are conscious, but that all their reactions are essentially of the mechanical and tropistic type. One must, of course, admit that we have no direct access to animal consciousness, if such exists, but the same thing is true of the consciousness of one's human neighbor.

It has seemed to me desirable to eliminate this whole issue from the present discussion, because we are primarily concerned with the demonstrable evidence of actions such as we can properly designate intelligent without regard to any particular psychic mould in which they may be cast. This is not because the question is devoid of interest—far from it—but because it does not lend itself to profitable discussion within the limits of this article, if we are also to make headway on the general problem of the evolution of intelligence.

Human Intelligence

How far the intelligence of modern man has developed beyond the stages of the prehistoric man, whose skeletons have in recent years come to light, it is practically impossible to state. Certain of these earliest remains indicate a cranial formation somewhat smaller than that of contemporary man and, although the evidence is precarious, there is perhaps some ground for thinking that the cerebral portion of the nervous system was less highly developed than now and that presumably the level of native intelligence was therefore lower. Nevertheless, this would be merely an hypothesis. If we turn to contemporary man, we find extreme variation in the culture and civilization of different races, and a widespread belief in equally marked differences in native intelligence. Thus the Occidental white man unhesitatingly puts himself at the head of the list, with the Asiatic ranking next, American Indians perhaps next, the African next, and at the bottom possibly the Bushmen of Australia. This list, of course, omits a number of important groups, but may serve to give some indication of a common type of arrangement. It is perhaps needless to say that the Asiatic in making out his list would accord a different position to his own group. Nor is any great racial stock disposed to accept an inferior status.

The question which is immediately raised by the most superficial inspection of these racial differences of culture and civilization has to do with the problem whether the European white man, for example, has by virtue of superior native endowment passed by evolutionary processes through stages of culture and civilization comparable with some or all of those now reflected in the several racial groups mentioned, or whether he has had an altogether different history. Have the civilized races, in general, evolved through superior intrinsic talent out of the conditions represented by savage races? The problem is

greatly complicated by the difficulty of separating out those factors which are indicative of sheer intellectual capacity and those which have to do with the accidental advantages of climatic or geographic habitat and the equally accidental developments of particular technical or social practices. It is easy to assume that more elaborate forms of civilization *necessarily* imply higher intellectual powers and this is perhaps not wholly true. So far as we can judge by the evidence in historic times, there is no reason whatever to suppose that the native intellectual abilities of the average American citizen are in any way superior to those of the Egyptians four thousand years before Christ, or the Homeric Greeks, or to others of the peoples of that general period in the Mediterranean basin, records of whose civilization have come more or less completely to our knowledge. It would certainly be a bold protagonist who should assert that modern European civilization has produced, in sheer intellectual power, men superior to Democritus, or Plato, or Aristotle, or Alexander, or Julius Cæsar, to say nothing of great Orientals like Confucius. In other words, since the period of historic records there is no convincing evidence of marked development in human intelligence, despite the enormous advances made in the paraphernalia of civilization; but, on the other hand, there is fairly definite evidence that extant human races differ appreciably in their native intelligence and those which are living most nearly in the state of nature which we believe to have characterized the early history of our own racial stock are, generally speaking, marked by apparently lower general average intelligence and by relatively fewer intellects of high grade. It seems therefore a reasonable inference that the forefathers of our own particular racial stock, could we but penetrate far enough into past history, would be found, like the more primitive races to-day, in possession of somewhat lower degrees of intellectual capacity. How many thousands of years we might

be obliged to go back to find demonstrable changes it is impossible to say. We know that the major anatomical characteristics of man have not materially shifted for the last twenty or thirty thousand years.

There is a very common popular belief that, although civilized man may be the superior of his uncivilized contemporary in certain forms of purely intellectual activities, he is his inferior in keenness of sense perception and in his response to many of the aspects of nature. Such evidence as we have tends on the whole rather to discredit both of the inferences involved in this assertion if they be made too sweeping. It is surely open to question whether all races of nature people now living are radically inferior to the more civilized groups in natural powers of intelligence. Certainly there are some striking individual instances of high intellectual achievement attained by representatives of some of these more primitive racial groups; and, on the other hand, there is good evidence for the statement that at least occasional representatives of civilized races are quite as keen in their vision and hearing—taking these two examples—as any of the primitive peoples with whom they may be compared. The North American Indian and the white frontiersman may illustrate the point. There are not a few instances of Indians who have exhibited intellectual capacities of a very high order, and the keenness of vision and hearing of some of the scouts of frontier history rival anything reported of their savage contemporaries. Training and discipline are perhaps in both cases the clew to achievement quite as much as deep-seated and indisputable difference of natural capacity—a statement which in turn must not be understood as implying that there are no significant differences between the lowest tribes of savages and the highest exemplars of civilization.

If, as a clever writer on these subjects has suggested, we may consider existing tribes of savages as in some sense our

contemporary ancestors, it is convincingly clear that, whatever is to be said of sheer native intellectual capacity, civilized man has developed a technique so superior to that of primitive peoples that his intelligence enjoys enormous advantages at almost every stage. It is peculiarly difficult for us to dissociate mere intellectual power from the cultural surroundings under which it is exercised. It may be, for example, that the inventor of the bow and arrow accomplished quite as great a feat in the intellectual world of his day as the inventor of printing in his, or the inventor of the steam engine, or the inventor of the electric light. Similarly, the inventor of the fishhook and the line, as a method of extracting food from the sea, may have enjoyed powers of native intelligence entirely comparable with those of our great modern inventors. All of which is but another way of saying that the evidences of the evolution of civilization and culture are far more striking and far more demonstrable than those which suggest, in historic times at least, any real progress in the intrinsic fabric of human thought. Moreover, in all comparisons of racial groups one must remember the astonishing variation of natural capacity in any large number of people. The psychological tests employed in the American army during the war exhibited the amazing range of capacity in a cross section of our population. Certain of the recruits in the army exhibited an intelligence capacity which marked them as morons and accordingly comparable with the most backward races. One is always tempted when comparing one's own racial group with another to take as the standard one of its very intelligent members. This is entirely unfair and sure to result in fallacious conclusions unless one is in a position to select from the group under comparison an equally exceptional representative.

But, after all allowances are made, it would appear that, if we compare the normal civilized man of any of the more advanced races with those savages lowest in the human scale, the

former is distinctly superior in the power of sustained attention and thought, in the range of things which interest him, and in his powers of analysis, abstraction, and inference. It used to be alleged that savages controlled their emotions less perfectly than civilized man. Inasmuch as emotional life is closely knit up with instinct and with the more primitive and ancient part of our nature, it would not be strange were this belief true. But when consideration is given to the different conditions eliciting emotion, it may be doubted whether this conception is in any unqualified way correct.

That portion of the history of man marked by any of the evidences of civilization is so extremely brief, compared with the vaster period of animal barbarism through which he must have passed, that we may well find it difficult to secure wholly conclusive evidence of evolutionary change in his mental powers. But such evidence as there is all points to a great *practical* improvement in the use of his native abilities.

When we contrast the conditions of savage man with those of any of the animals, even the highest primates, the differences in apparent intelligence are very marked. It would hardly be a safe statement that animals make no use of gestures, whether vocal or otherwise, to serve the purposes of a rude language. But such use as has been reliably demonstrated is so crude, so largely a mere expression of emotional excitement, that compared with developed human speech (which presumably developed out of emotional expressions) it is a hopelessly imperfect tool. Primitive man as we know him, although often carrying on his affairs with an extremely limited vocabulary, nevertheless is able, through his language devices—to say nothing of others—to mark off and deal with abstract and general relations and in so far he enjoys a technical superiority to the animals which, in effect, is a difference in kind as well as a difference in degree. Moreover, broadly speaking, animals make no use whatever of tools. The occasional instance of

the elephant brushing off flies with a branch held in his trunk, or the alleged instances of monkeys using stones to crack nuts, are but sporadic examples of probably accidental achievements which in no case lead on to any general ability to make use of utensils in a discriminating way. One must not, in this connection, confuse with intelligent actions the remarkable instinctive manipulations which many animals are capable of, nor the tricks which they may have been taught by long and painful effort. The elaborate nests which many birds build are amazing instances of utilizing the most varied materials in highly complicated forms. Similarly, the beavers accomplish the most astonishing results with the materials which they employ and there are abundant reports of their adaptability to changing conditions which, if well established, are certainly suggestive of highly intelligent reactions. Here again, however, the experimental zoölogist who has studied most carefully the instinctive activities of animals will be most hesitant to ascribe individual intelligence comparable to that of man in interpretation of these animal reactions. Certain it is that, generally speaking, the primates are much more skillful than other animals in adapting themselves to shifting conditions and that, even among them, the evidence of anything comparable with a human process of inference, or a process of abstracting, or of generalizing, is very, very slight. In any case, the issue which is raised here again must be clearly understood, to wit, that beyond the adjustments which are innate, inherited, and unlearned by the individual are those which represent his individual acquirement independent of such inherited tendencies. The latter is the field of individual intelligence.

As was indicated earlier in this paper, there is a wide general correspondence between the degree of intelligence manifested by animal forms and the structure of the nervous system. In particular, intelligence in its narrower and more specific sense, as distinguished from instinct, appears to be rather a

function of the cerebrum and particularly of the cortex. If animals are arranged in the order of the development of this organ in the nervous system, the relative size and complexity of it will be found standing roughly in parallel with the variety and adjustability of the reaction patterns. That is to say, an animal that has a well-developed cerebral cortex will have a richer type of behavior, being less completely dependent upon instincts and reflexes and being capable of carrying out a larger range of activities than can an animal with less fully developed cerebral structures.

Man has, as the great differentiation of his own brain from that of most other animals, a very much more delicate internal structure in the cortex and relatively very much larger parts of the cortex devoted to the interconnecting and interrelating of the various parts of that organ with itself. The frontal areas and the so-called association areas are relatively very large. Some of these differences are demonstrable only under the microscope; others, however, are obvious even in the gross anatomy. But despite these differences which are real, no one could ever have inferred from them such marked differences in the expressions of intelligence as do in point of fact distinguish man from even the most highly developed animal. The general pattern of the human nervous system is, broadly speaking, exactly that of wide ranges of the mammals and more particularly of the primates. Nevertheless, the behavior of man is certainly very different (even though the difference be thought of as merely quantitative and not as qualitative), especially on the levels of memory, imagination, thought, and reflection. On the whole, man's development and control over language is unquestionably the greatest single achievement which his intelligence has compassed, and whether one thinks of it as cause or effect, its presence, more than any other one factor, is responsible for his enormous superiority to his animal neighbors. It has enabled him to achieve social coöperation and the fixa-

tion of institutions, to preserve tradition and modify its coercive influence by rational discussion, and incidentally it has afforded him the most powerful single tool for creative individual thinking.

The striking character of the difference between typical human processes of inference and those by which animals acquire wholly new reactions may be illustrated by a single example. Here is a dog shut up in a cage with his food just outside the door. To open the door and satisfy his hunger involves pulling a cord which lifts a latch. No matter how obvious the arrangement to human vision, the dog may thrash about for a long time in the neighborhood of the cord, biting and clawing the various parts of the cage, until by accident he may seize the cord in his teeth and forthwith escape. A human being having once found a single act which would thus open the door would ordinarily require no second experience instantly to repeat the success. But the animal may need many such trials before establishing the correct response, showing that there is very slow discernment, or possibly none, of the real relation of the cord to the opening of the door.

Now human beings do many things quite similar to the random activities of the animal in the cage. Many a child attempting to solve a mathematical problem does exactly the same thing and comes upon the correct result, if at all, quite accidentally and as the outcome of a kind of mental fumbling. Indeed, all elaborate thought processes inevitably have in them much of this more or less haphazard experimental venturing. But the point is that once the human being clearly sees the relation involved, he can immediately repeat successfully the process and generally carry over the principle to other similar but not identical problems. It is doubtful if animals ever do just this thing. Even their powers of imitation are far less than is commonly supposed.

So, despite the structural similarity of the brain of man and

the brain of the higher mammals, the differences in intelligent behavior are very marked. The most intelligent animal is probably in the mental condition of the young baby or the very low grade moron, and this despite the possession of instincts which often enable the most astonishing adjustments to environment.

Future Development of Human Intelligence

One of the speakers in this course raised a question, which has enjoyed a good deal of attention, and to which a further word may perhaps be added in this connection. Is the evolutionary process at an end so far as concerns the human brain and human intelligence? In the nature of the case no dogmatic reply can be offered with confidence and one must fall back upon the probabilities of the case. I cannot altogether sympathize with the somewhat definite negative opinion occasionally advanced, for such negation has its chief justification in the vast extent of time throughout which little or no demonstrable advance has occurred in the organization of the human brain and therefore presumably in human intelligence. One cannot challenge the fact that for many thousands of years there has been little or no such change; but, on the other hand, the period of time for which we have such evidence, twenty or thirty thousand years, is so trifling compared to the total life of the race and the total duration of life itself on this planet, that a prediction based on such a relatively insignificant segment of man's history seems highly precarious. Assuming some extra-mundane observer of the primeval slime out of which organic life has come, it would certainly have seemed to such an one grotesque to predict such changes as have actually come to pass, and particularly as regards intelligence. Similarly it is entirely impossible to surmise at what point progress beyond present human capacities may occur, but to

conclude with any certainty that such further progress will not occur, much more that it cannot occur, seems hardly warranted.

Whether this view regarding the further evolution of intrinsic human capacities is right or wrong, there would appear to be no practical limit to the changes which man can hope to bring about in the conditions of his life by the further application of the same technique which has produced the highest forms of modern civilization, has produced our fine arts, and, particularly, has produced our modern science. Conceivably we shall never have greater epic poetry than that of Homer, greater sculpture than that of Phidias, greater architecture than that of the Parthenon, greater drama than that of Shakespeare, greater painting than that of Raphael and Titian, greater symphonic music than that of Beethoven. There is, however, nothing to prevent advance upon such achievements and in the range of the natural sciences at least, thanks largely to the perfection of experimental technique and the utilization of mathematics, there seems to be literally no limit in sight to the further mastery which man may achieve over the forces of nature and consequently no limit to the alterations which he may be able to introduce to the enrichment of civilization. Even in the field of religion, where obvious evolution has occurred since primitive times, the modern mind has introduced modifications of the teachings of the founders of the great world religions designed to adapt them more nearly to the conditions of contemporary life. The doctrines of Christianity itself, while based as truly as ever upon the life and teachings of Jesus, are undergoing constant development and transformation designed to accommodate them to the needs of the life and thought of our time. Strangely enough, the scientific mastery of the facts of man's own nature and the laws which control society linger far behind the corresponding insight into the nature of the processes of the physical world. But surely it is only a matter of time when these social sciences,

so-called, will also have perfected a technique enabling man to secure mastery over himself and his social relations comparable with that which has begun in the control of physical nature.

In modern times, to mention but a single point, our knowledge has been rapidly growing in regard to the extent to which the mental life of the individual human being is subject to influences which rarely or never show themselves above the level of his conscious life, and, even upon these infrequent occasions, come so screened and shrouded that their real origin is seldom understood or appreciated. It has thus been made particularly clear in the last century that man is in his instinctive life close cousin to the brutes. But he has also in his nature the deep grounded tendencies of hundreds of thousands of generations of savage human ancestors. Furthermore, he carries into his adult life many prejudices, fears, likes, and dislikes, which trace back to his own infantile and childhood experiences. Any of these tendencies may well up at a moment's notice to affect the attitude which he takes toward any issue that may present itself in his life. He may make a decision which, with a not unnatural self-flattery, he calls a carefully reasoned choice. But to a sufficiently informed observer it would frequently be revealed that this reasoned choice represented an attempt to justify on rational grounds an impulsive preference arising from some of these hidden springs in human history, rather than a wholly disinterested and unbiased analysis of a given situation. Moreover, man at birth finds himself instantly surrounded with all the traditions and practices of his own time, race, and social group, which from the very beginning hem in his spontaneous activities, furnish the stage upon which his instinctive and impulsive life must be played, and, in general, set boundaries which, however independent, he can hardly cross. In point of fact, the average individual is intensely conservative, indisposed to the

labor and the hazard of independent thinking, a creature of habit, most content when most easily able to run along in the fixed grooves of daily life without friction or annoyance.

Nevertheless, while the average individual may be intrinsically indisposed to encourage change, except in those circumstances which occasion him personally acute discomfort, the more active and progressive minds find through the accumulated knowledge of the race, now for a few centuries available in permanent written form, and through the amazingly rapid development in the technique of the sciences, the tools at hand for a literally unlimited evolution in the actual conditions of human life. From this practical point of view, therefore, the evolution of intelligence may be considered as close to its beginnings rather than in any sense drawing near to its close.

CHAPTER V

SOCIETAL EVOLUTION

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The essence of evolution is the development of form out of form, in a connected series, with survival of the fitter forms in adjustment to environment. The outcome of evolution is adjustment of life to life-conditions. No informed person feels any longer the need of arguing the truth of the theory; interest now centers in the extension and correction of knowledge as to the details of the process, and in the applications of the truths discovered. In the Darwinian theory of adjustment we have one of those widely orienting factors which array knowledge in orderly vistas and lead mankind to believe that there is some sense in earthly existence.

If there is any one place rather than another where mankind would like to find sense and order, it is in the field of human social relations. No one can read the vivid pages of Henry Adams's *Education* without a deeper appreciation of the darkness and deviousness of the ways along which all of us are traveling, though most of us are not so conscious and concerned about our gropings as was that anxious and rueful searcher after enlightenment. Adams, an evolutionist believes, was after too much. He wanted to find some norm of progress in human history, and seems to have renounced high hopes of Darwinism when he found that it offered no such norm.

It is one of the common misconceptions about evolution, and

one into which Adams fell, that it means progress. It means adjustment only. Such adjustment seems to be progressive if it leads in a direction which we choose to call forward; but it may appear also to be retrogressive if its runs counter to that direction. To us the change from the flint-lock to the percussion-cap musket seems a progressive adjustment, and the return from the latter to the former, in hot and damp regions, where the cap deteriorated while the imperishable flint did not, appears to be retrogression. Both were expedient adjustments to life-conditions.

We ought not to be dismayed at the sight of forces operating in what seem to us opposite ways, at one and the same time. We should not bemoan the failure of evolution because motion is not always visibly in the direction we like or expect, any more than we should despair of gravitation because it causes both the stone to fall and the balloon to rise. The fact is that the terms progress and retrogression, as their etymology indicates, imply that the user of them has selected some center of operations from which he can infallibly adjudge what is "pro" and what is "retro." He is at liberty, in free countries, to do this for himself and to try to persuade others that he is right; and sometimes whole groups can agree on what is progress and what is not; but it is generally impossible to get extended unanimity as to the identity of "forward" and "backward." Especially is this the case when it comes to the appraisal of social relations, institutions, and policies.

But this whole difficulty is escaped, in the case of evolution, if we consent to view that process as it is, and do not, in our straining after the assessment of things as progressive or retrogressive, hug to ourselves the misconception that evolution and progress are synonymous. If we simply ask, concerning any organic or social form, whether it is an adjustment, past, present, or pending, we shall all find ourselves in a substantial agreement that will permit of our going along farther

together. I myself think the protective tariff to be a case of retrogression, but that does not prevent me from agreeing with its many ardent and even candid sponsors that it is an important adjustment to life-conditions. I regard the League of Nations as the only practical and working proposition in the field of international relations; others think it a foolish and retrogressive measure; but all of us could agree that it is a widely accepted adjustment, now under test. Slavery was once an adjustment that everyone believed in. The time came when conditions changed and there arose a difference of opinion as to whether it was good or bad, progressive or retrogressive. Now it has come to be regarded as a maladjustment. But, whatever the judgment upon it at various times, anyone can see that it has been one of the ways into which men naturally fell in meeting the conditions of life as presented.

I have used, perhaps, a disproportionate amount of space in seeking to enforce this point; but I have done so deliberately, because there is no other range in which people are so wont to set up private and local standards, upon which they then assess all things, as they are in the range of social life. If many are disposed, petulantly or dismally, to despair of organic evolution because it does not support their ideas of progress—which it never set out to do, any more than it advertised to explain the origin of life—how much more darkly would they despair of a social evolution that lays no claim to be progressive. Man's dearest interests are vitally involved in his social life; in fact, what discouraged Adams and others with Darwinism was not its givings in the organic field, but its fallings-short, in promise, of their hopes in the social field—into which it was speedily and incontinently dragged by the almost instinctive tendency to "reason from analogy."

I cannot go into this last matter—of how conclusions were drawn concerning the nature and life of human society from the nature and life of organisms. It was partly Darwin's fault

for embarking upon the discussion of social and moral matters, in the *Descent of Man;* matters concerning which he was little better informed than any other non-specialist. It was still more the fault of Spencer, who became so enamored of the analogy between organism and society that he came almost to believe it an identity. Then the Germans got hold of it and constructed huge volumes of uninspired muddlement about the "structure and life of the social body."

The analogy between a society and an organism is a pretty one, as developed by Spencer. Its development was not without use. But of what use? It is of no use at all in proving anything about society. An analogy is no proof of anything. Consider the exhorter who described the life-cycle of the butterfly and wound up triumphantly: "Now who shall say that there is no proof of immortality!" Proof demands facts, ever more facts, all sorts of facts bearing on the subject. Out of them comes the theory, and from them the theory is corrected and re-corrected. It is most essential that the facts shall not be selected, either to be acclaimed or to be ignored.

An analogy, on the contrary, is a specially selected fact or relation. It is picked out of many possibilities because it is thought most vividly to set forth some idea already developed and fixed in mind. It is not the search for truth that the analogy-user is after; it is the exposition of a position already taken. Analogy is perhaps the most effective device for exposition; but it is the tool of the preacher, not of the discoverer. Its supreme effectiveness is found, probably, in the parables of Christ,[1] who, in trying to transmit spiritual truths to simple minds, took recourse to homely analogies on all sides.

There can be no direct "reasoning from analogy," therefore. People who write on social evolution are regularly charged with trying to do that, and generally justly; perhaps if a writer starts out by saying that it cannot be done, it will

[1] For example, Matt. xiii., 31, 33.

be believed by some of his readers that he is not endeavoring to do it.

But the analogy, correctly understood and not burdened with a weight it cannot carry, can perform a service of great value. If in one field of investigation (say the organic) we know that certain phenomena are produced in a certain way, and if in an adjacent, less understood field (say the social) we find analogous phenomena, we are justified by long experience in the inference that the unknown producing factors in the new field are probably similar to the known ones in the older range. If, in particular, we find adjustments in the organic field produced by the so-called Darwinian factors, and if we discover that the social range shows social forms representing adjustments to the life-conditions of society, it is reasonable to infer that the factors producing social adjustments may be similar to those producing organic adjustments. This is the more likely in view of the fact that all members of human society are organisms, so that the two ranges—of organic and of social life—are not merely contiguous, but interpenetrative. If organic forms are evolved by the action of the Darwinian factors of variation, selection, and heredity, their joint action resulting in adjustment to life-conditions, it is a hint to us that, in default of any more promising lead, we had better look for counterparts of the Darwinian factors in the social range.

This suggestion has been unreflectingly and unconsciously adopted in popular usage. It is seen that habits and customs are passed on from generation to generation somewhat as bodily qualities are. It is necessary to use some term to cover the process. The biological term is heredity. It is easier to catch up a term in use than to invent a new one. Hence writers speak of "social heredity." It is like speaking of "brass andirons." However, it is vaguely realized that habit and custom are not transferred by actual heredity, through the germ-plasm; and the perception of the unanalyzed difference

involved is indicated by the adjective "social"—not plain "heredity," but "social heredity." The upshot of the matter is that even the casual observer has noted the likeness between things social and things organic and biological.

It seems to me that we had better take this hint from analogy and work on it. Evolution is proved and accredited in the organic field; at Darwin's centenary scientists of all descriptions united, in a volume called *Darwin and Modern Science,* in bearing witness to the fruitful suggestion received by them from the Darwinian theory. We had better see whether that theory can not help us in discovering some order and sense in social phenomena. I think it has helped some of us in just that way. Our courses in the science of society, representing the best we have to give to our students, have for many years begun with the effort to make sure that they all secure a layman's knowledge of organic evolution.

My predecessors in this course of lectures have shown that the evolutionary process does not stop short of man as an animal. Huxley,[2] in comparing him with the anthropoids, summarizes as follows: "Thus, identical in the physical processes by which he originates—identical in the early stages of his formation—identical in the mode of his nutrition before and after birth, with the animals which lie immediately below him in the scale,—man, if his adult and perfect structure be compared with theirs, exhibits . . . a marvelous likeness of organization. He resembles them as they resemble one another—he differs from them as they differ from one another." But if man is thus similar to the animals, it would appear that he must come under the same need of physical adjustment to life-conditions. If so, he should show differences comparable to those exhibited by animals as the result of adjustment to widely diverse life-conditions. Being the most widely ranging of all animals, he might be expected to

[2] Huxley, T. H., "Man's place in nature," 1901, p. 83.

show the greatest physical diversities. He does not. Does this mean that evolution stops short of man? Let us first get some of the facts before us.

Human beings are much alike over both time and space. For many thousands of years man has been substantially the same kind of a physical being as he is to-day. Over all the earth he is pretty much the same sort of animal. One who has followed the efforts of scientists to distinguish the varieties, or races, of mankind can realize how essentially alike they are. Conviction of this essential similarity has led to the assertion that "man is unchanged in a changing environment." But this seems to mean, on the face of it, that somewhere during the course of human development evolution is suspended; for evolution is adjustment to environment.

Certainly mankind has encountered widely diverse environments. Men live in countries where the temperature falls far below zero; also where it rises considerably over one hundred degrees Fahrenheit. They inhabit regions which are cold and dry, cold and damp, hot and dry, and hot and damp. They live at sea-level or thousands of feet above it. They persist where there is much animal life of all kinds, or where there is little of any kind. Of all animals the most widely distributed over space, men have encountered all varieties of earthly environment. Yet they are essentially alike. The most widely distributed; the least changed—"unchanged in a changing environment."

Through time also, with its secular and often radical changes of life-conditions, alteration in man's physical make-up has been relatively slight. Animals adjust even to so regular and recurrent a set of conditions as the succession of the seasons, while man has remained practically the same through the protracted ups and downs of centuries and millenia. Is it possible that the evolutionary process is stayed and that man is exempted from it? Of course it is not halted; and he is

not exempt. The process merely changes its mode. It is no longer evolution of the organic type, resulting in structural adjustment; it is evolution of another grade, resulting in another sort of adjustment. There must be adjustment just the same, as a condition of existence. Evolution goes on as long as adjustment to immutable life-conditions goes on—that is, as long as life lasts. It is this typically human phase of evolution which we want to identify and examine.

When human beings get into a situation (a cold climate, for instance) which, for animals, evokes physical adaptation (such as a thicker coat), we find, perhaps, some small adjustment by way of bodily change; but typically and generally what we see is the employment of materials external to the body—skins, wood, metal—which are interposed to form the instruments of adjustment. It takes a certain brain-action to arrive at such utilization of the things available in nature. When bees build combs, it is by an instinct that represents a single adjustment, once and for all, whereas man has, in the brain, a sort of specialized adjustor capable of being turned upon this and then upon that situation. His brain is somewhat like one of these tool-handles which include in one instrument the possibility of a variety of operations, except that the brain is infinitely more protean in its transformations.

The brain clothes its adjustments in material form. They are thus realized or made real—materialized, or rendered in terms of matter—externalized, or worked out in things external to the body. Every such realized thought is a piece of culture or of the apparatus of civilization. Such are the climbing-irons of the linesman, which are the cultural counterpart of the natural climbing-foot; such is the aëroplane, as compared with the wings of the bird. Tools, weapons, houses, parachutes—all these are objects of material culture which are counterparts of what nature has developed over countless ages of organic evolution—for the beaver, whose tools are teeth;

for the stag, whose weapons are hoofs and horns; for the nautilus, whose house is his shell; and for the dandelion seed, which sails about on its supporting structure.

But not all these cultural products are made of substances. They are often immaterial forms of organization and conduct. Specialization of labor is a cultural adjustment for readier self-maintenance, saving as it does time, effort, and material, and yet winning to a better product. Marriage is a cultural adjustment by which two very differently endowed sexes get along together and rear young. Government is a cultural adjustment resulting in orderly and peaceful human relations. All economic, political, and other social systems, economies, and institutions are cultural adjustments to life-conditions of maintenance and sex, and of others presented to men in their earthly life. Good government is as much a favorable adjustment as is the web foot of a duck, and polygamy is as obsolete an adjustment for us as five toes came to be for the horse.

If this is so, the fact of adjustment, and the need of it, is as patent in the case of mankind as it is in that of other animals or of plants. Only it is attained, in the former case, by factors not precisely the same as in the latter. We shall come to these factors presently. The outstanding fact, thus far, is that plant and animal adjustments are typically physical, while human adjustment is typically not physical. It is mental.

It is also social. Civilization is the product of numbers and the contact of numbers. The new invention, representing a better adjustment to life-conditions, say the gas-engine, never springs full-fledged out of the brain of any individual. The one who gets the credit for it is at best but the last of a long line of experimenters, who has added the finishing touch—where, indeed, he is not the exploiter who merely appropriates the results of a long series of labors in which he has borne no part. Much less did any individual invent marriage or property, though tradition sometimes accredits them to a mythical

law-giver. To arrive at any of these cultural adjustments demands the give and take, and the gradual accumulation, possible only where there are a number of human beings coöperating in the effort to maintain and perpetuate the race, that is, in a society. Cultural adjustment is therefore social; or, better, since the word "social" is so vague, it is "societal." It is a thing that occurs only in society. It is "of society," and that is what "societal" means. The securing of such cultural adjustment is, therefore, by "societal evolution."

This is the new mode or grade of evolution that replaces for man the organic mode or grade. Organic evolution goes but a short way in explaining human relations, even though, since man remains always an animal, it is basic to the whole of human existence. Natural selection continues to operate upon men, for instance, through the ravages of some diseases;[3] but in general it is replaced by another kind of selection which may be called societal. Natural selection could never result in a religious adjustment, for example. Such an adjustment is not of the organic grade. At best, natural selection cannot exceed that grade; in fact, it is a risky contention to assert that even the fittest human animals are surviving and multiplying in comparison with the unfit. The alarmists about race-suicide, counter-selection, racial degeneration, and the like, are complaining that we are breeding all the time from the worse elements in the population. We may be, if animal-fitness is the sole criterion; and we may be, even though we realize that there are other criteria. But it is essential to note that societal fitness—fitness to be a member of society—is not identical with physical fitness. It is enlightening to run over a list of those men who have served society best and see how many of them were physically defective.

If natural selection is not effectively in operation in preserving the fittest human animals, because societal criteria

[3] Holmes, S. J., "The trend of the race," 1921, chs. VIII and IX.

always cut across organic criteria, it is certainly out of its range when it comes to institutional development. If we read that cannibalism or feudalism has perished by "a sort of natural selection," the very qualification in the phrase indicates that the user of it is merely employing an analogy. We are, I repeat, upon another plane of evolution where the processes and survival-values are somewhat altered from those existing in nature. The attempt to carry natural selection over to the new plane is wholly unproductive.

It is understood, then, that evolution in the societal range is of a different kind, quality, brand, or variety from that operating in nature. Societal adjustments, we go on to infer, are probably produced by the operation of factors present in the organic field, though these factors must needs be somewhat metamorphosed in their manifestations in the societal range. To one who has in mind such considerations as the foregoing, there is nothing to do but to try out the Darwinian factors upon societal phenomena. But upon what shall he try them? Of course, upon the aforesaid cultural adjustments: inventions, systems, economies, organizations, and the rest. Are these societal adjustments, like the structural ones of plants and animals, the end-results of variation, selection, and heredity, operating in their societal modes and manifestations?

A great many of the cultural adjustments are, as we see them in institutional form, as in marriage or religion, immensely complex. It is expedient to seek them in their simpler phases, just as one would reduce a complex fraction in order to be able to handle it. The simplest form of all societal institutions is custom. They all come out of it. Custom is also a conception difficult to handle because it is all-pervasive and eludes the grasp. It required a sort of *tour de force* to seize, define, and thus reduce to usable form this elusive and floating conception. This was done by my predecessor, Professor

Sumner.[4] I am bound to say that he did not give much attention to the possibility of extending evolution into the societal field;[5] but he furnished, in any case, the necessary basis for such an enterprise. We shall review his findings in their salient aspects.[6]

When the first societies of which we know appear to view, they are already provided with a set of ways, or a traditional procedure, by which they carry on self-maintenance, and every other of their activities as well. These ways represent a concurrence of group-members in the practice of expedients, economic, political, religious, or other, which have been proved to them, in the event, to be successful ones. These expedient ways have been called the folkways or mores. Language is one of the most typical of the mores; division of labor is another. No one planned them, but they grew up and are practiced unquestioningly, unconsciously, and automatically. They correspond to habits in the individual. Taken all together, they constitute the code of behavior in a society. They represent the proper way to act, and, even though they are not subjected to any rational or critical examination, there exists the conviction that they are the only right ways, the only ones fit to live by. The mores, says Sumner, are "the popular usages and traditions, when they include a judgment that they are conducive to societal welfare, and when they exert a coercion on the individual to conform to them, although they are not coördinated by any authority." It is just as well to have a technical term for them, for they are not precisely customs, or social habitudes, or ethics, or morals.

They become uniform and universal in a group, and also imperative; and, often over long periods, they are so resistive

[4] Sumner, W. G., "Folkways," etc., 1907.

[5] Cf. Keller, A. G., "Societal evolution," 1915, pp. 328-330.

[6] Certain of the following paragraphs are a reproduction of Keller, A. G., "Through war to peace," 1918, parts of chs. VI and XVIII.

to change as to appear invariable. Many of them are strongly sanctioned by religion; in fact, practically all of them that are of long standing are supported by the readiness of the spirits, ancestral or other, to punish infringement or alteration. They thus come to form a prescribed body of rules of behavior for life in society that well deserves the title of "the social code."

Within the range of societal self-maintenance, the mores determine how the struggle for existence and the competition of life shall go on, thus rising to meet and cope with certain vital and perennial life-conditions. Another inescapable and vital life-condition is laid down in the bisexuality of the human race; there are the relations of the sexes to be ordered, in the interest of the society's well-being. Innumerable mores attend upon the association of man and woman, parents and children, and they work out into various forms of marriage and the family. A big group of mores always surrounds some vital condition of society life, like that of sex, and forms the approved method of dealing with it. Another such condition, for further example, was felt in the vividly conceived presence of a world of ghosts and spirits, an imaginary environment to which men adjusted themselves by the unplanned development of a set of mores covering forms of avoidance, exorcism, conciliation, and propitiation of spiritual beings.

But these several sets of mores, "mere custom" at first, gradually attained a stage of organization where they became institutions, as, for example, matrimony or religion. There is no human institution that has not risen from the matrix of custom; the rise of new institutions, now as always, is out of the same prolific source. And, as they take more definite form and somewhat disengage themselves from the mass of custom, the institutions do not lose, but carry with them, that approval and that conviction as to their indispensability for welfare that were accorded to the mores. Anything that is in our mores is right, and so our institutions are the best. "The

mores," says Sumner, again, "can make anything right and prevent condemnation of anything." They are the approved ways of meeting the conditions of living, and are developed, accepted, and practiced without much intervention of reasoned purpose.

They are to a society what, for example, density and color of fur are to arctic animals; namely, automatic adaptations to environment. Life-conditions are present and society has to live under them. This is rendered possible, or easy, or easier, by adjustments in the manner of life or ways of living. Thus we have a societal code characteristic, for instance, of the arctics or of the tropics, of isolation or accessibility, of over-population or under-population, of the country or of the city, of peace or of war.

With this understanding as to the nature of custom, the lowest terms of all of society's institutions, and knowing that customs and institutions are adaptive to life-conditions, we are now to inquire whether there are, acting upon the mores, forces which are the counterparts of those productive of adaptation in the organic range. Are variation, selection, and heredity, or factors which are their counterparts in the form of evolution typical of human society, present and active in the field? If so, what is their mode of operation?

The factor that leads off in any evolutionary process is variation. Without it all would be uniformity, equality, and changelessness. The existence of variation in custom and in custom-born institutions is evident to anyone; demonstration of its presence would consist in an endless rehearsal of obvious detail.

Variation in the mores represents a series of tentatives, departing more or less from the accepted code, that are struck out upon by individuals in the pursuit of their interests. The individual's function is that of an agency for variation. These slight departures from the code are in evidence all the time; in

fact, the society's code is a sort of average or mean or type, about which cluster the codes of classes, sects, and other larger and smaller sub-groups. The individual may adhere to a number of these sub-groups, as his interests dictate. He may belong, for instance, to the miners' union, the Baptist church, the Socialist party, the Masonic lodge, at one and the same time. When interests change, other and new codes may appear, some of them departing widely in character, perhaps, from the general or typical code of the society at large. In general, the rise of such variations is a consequence of discomfort under the prevailing code; interests strain toward a better realization by way of change, small or great.

It is to be noted that variations upon customs and institutions may exhibit a high degree of rationality. They may represent true experimentation, because they may be set forth consciously and deliberately, after intensive study of situations and of societal laws, with the intention of securing more expedient adjustment of society to its life-conditions. But they come to nothing—they do not get into the mores—unless there is general concurrence in them. They remain stillborn unless verification is immediate, concrete, and positive. Rational variations—new details in the program of adjustment—are presented in every age. Whether they are adopted or not is another matter, for, as we shall see, there is not much of the rational in the selective process, except as the latter is seen, in retrospect, to have worked out expedient adjustments through the action of human agencies inspired by the most diverse and often irrelevant motives. If deliberate and planful action enters anywhere into the process of societal evolution, it is in connection with variation; for variation is, as we have seen, very much in the competence of individuals, and it is the individual, not the crowd, that will occasionally be found to think in terms of society.

Among these variations, whatever their provenance, selec-

tion takes place. Such variations may be short-lived and exhibited by only a few, or there may be a concurrence of many which carries them forward until, perhaps, the code of the society at large has been profoundly modified. Some of the variations live and some die out. Here is the fact of selection. All through history, codes and institutions have appeared, have persisted for a time, and have been altered or have passed completely away. But the process of societal selection is somewhat involved. I should prefer, for the moment, merely to record its presence.

The remaining factor is heredity. It is clear enough to anyone that the mores are not inherited but learned—acquired anew by each generation. Language is the best example: men have used it time out of mind, but no one is ever born with a command of it. Mores are also passed over from one group of adults to another. Hence heredity is not present in the societal range. But there is something there which discharges essentially the same function and is a genuine counterpart. Without variation, we have seen, all would be monotony and changelessness; but without heredity or some factor similarly conservative, all would be chaos and discontinuity. Even social life is not altogether that; and it is not that because in it too there operates a conservative factor.

Transmission of the mores is by tradition. What matter if its channels are through the eye and ear, and not by way of the germ-plasm? Tradition, like heredity, tends to repeat the type. It is brought about through imitation, either spontaneous or induced. Spontaneous imitation is a natural activity, common to animals and man, and especially marked, among human beings, in the young. The receiver of the mores, thus transmitted, wants to receive, and takes the initiative in the transfer, as when the small boy apes his father. But such acquisition is also capable of being induced, where there is no likelihood that it will be spontaneous, by precept and disci-

pline. This is education, in its broadest sense. The receiver may be indifferent or even unwilling to receive, and the giver commonly takes the initiative, as, for example, in the "uplifting" of a "lower" race. Also, while spontaneous imitation carries all the mores indiscriminately, education carries a more or less wisely selected body of mores. It is clear that the former is the more natural, elemental, impersonal, spontaneous, and automatic process; the latter is effective as it succeeds in reproducing the essentials, at least in semblance, of the former, but in comparison it appears artificial. It involves, it has been noted, an antecedent choice or selection from the main body of the mores: we will teach the young certain things, and others we will try to keep from them as long as possible. This choice is supposed to be a reasoned and purposeful one; but such a selection has little of the sureness and severe correctness of an automatic selection.

These evolutionary factors are operative in the life of every society, from the family group to the nation. And they do not stop there. They are effective, on the grand scale, in the life of human society as a whole. There is a world-code that has been in process of formation with the establishment of proximity between the nations; for that proximity, brought about by the annihilation of distance, has meant altered conditions of life for many societies; and variations that have been demonstrated, under selection, to be expedient, have been transmitted until enough mores have come to be held in common by all, or nearly all, to justify the term "international code" or "world-code." Variations around this code, or in departure from it, may now be originated by a whole nation, and submitted for world-wide acceptance or rejection. Slavery, for example, has been rejected, while democracy has widened its range. And of late has stood forth Germany, as champion of a code that is still undergoing the ordeal of selection. These national variations on the world-code cannot be tested up as

soon as, or shortly after, they appear—as Mormonism was tested up on the American national code—and the process of selection is the more imposing when it comes. We turn now to a survey of the essentials of the selective process.

It is about the factor of selection and its operation that the students and experts, genuine or alleged, in the social sciences, are at considerable variance. Few would dispute the operation of variation and transmission; hence I have reserved the contentious topic of selection for special consideration. And first let us be clear as to what "selection" means. The ordinary use of the word conveys the idea of picking out something desirable or good from a collection of things not so good or not so desirable. Such a conception of selection is a positive one. But that conception ought not to be carried over to color either natural selection or societal selection. The truth of it is that it is the unfit animals and plants which are selected —for death—and it is incidental to that process that we have a "survival of the fittest." It is the inexpedient custom that is selected—for disappearance—and it is incidental to that eventuality that the more expedient custom or institution survives. The useful conception of selection is therefore a negative one. If one does not get this firmly into his head, he is likely to be looking, in the primitive way, for some benign or malign agency where only impersonal natural or societal law prevails.

To attain to selection there is need of struggle and competition. It is not by discussion nor by guesswork nor by soulful yearning that the relative speed of several runners is settled; it is by a race. In nature there is the struggle for existence, and plant or animal forms succumb under it. Well, the life of societies also has been characterized by perennial struggle. It is sometimes to the death, and under such circumstances the selection is sharp and decisive, as it is in nature. Again, however, failure in the societal struggle is not visited by such dire penalties. Competition between societies runs all the way

from wars of annihilation to rivalries in things of the spirit. The degrees of intensity of selection among the mores correspond to the degrees of violence and decisiveness in this competition.

The ultimate form of societal selection—one from which there is no appeal—is the war of annihilation. It was the tribunal before which all the earliest and most important collisions in societal policy were settled. War is still the court of last appeal when all milder forms of settlement have, as in the year 1914, failed. It is not supposed to involve annihilation nowadays, though, as the popular fancy noted, the treatment accorded Belgium and northern France savored of Attila the Hun.

Of course the mores do not fight each other, though we say, figuratively, that Protestantism fought Catholicism, or that there is a warfare between religion and science. It is not the codes of mores that fight; it is the men practicing the codes who do that. But the codes rise and fall with the successes of their sponsors in the competition. If a tribe that practices cannibalism comes into collision with another which abhors the custom, and is overcome, there is not likely to be much anthropophagy in that region for some time. For even if the conquered cannibals are not massacred, but enslaved, they lose, along with their power, their self-determination in the matter of their code. I think it will be clear, upon reflection, that great wars generally issue in so-called "new eras," "new worlds," or "new dispensations," which mean new codes of adjustment.

In the course of time the minor collisions of codes have come to be settled without much or any bloodshed. Enlightened states refuse to concern themselves much about the religious beliefs of their constituent groups, where once execution and persecution were rife. Revolutions have been tamed down into elections. Commercial and industrial warfare is carried

on at the polls. Ballots replace bullets. But selection goes on just the same, so long as there is a competition, with winners and losers. Bagehot[7] has an important chapter on the "Age of Discussion," from which it appears that the voice and the pen have somewhat ousted the sword in the settlement of codes and policies.

This is not the place to go fully into the various forms taken by societal selection. It is plain enough, however, that there are plenty of them. It is only because they are so much a matter of course, being registered daily in the press for anyone whose attention has been called to their bearing upon societal evolution, that it sometimes comes as a shock, especially since we are nourished so largely upon romance and phantasms, to see that competition is always the indispensable precondition to development. If we think we have got on since primitive times, we may set it down to the diversities produced by variation and shown up in the incessant conflicts between men adhering to their differing codes. There is no fault to be found with the effort to minimize the tragedies of competition by setting up rules of the game; but those who dream of universal equalization, communalization, and pacification are proposing to abandon the agencies which have brought us from savagery to the civilization which we now acclaim.

The recurrent dispute about societal selection is as to whether or not men deliberately plan out and realize society's destiny. The plants and animals are supposed by most people to be under the sway of a vast force which they can in no way control; natural selection is thought to operate over them and to determine their destiny, as it were, from without. So far as they are concerned, they seem to be totally unconscious of what is going on, and have no say about their own destiny. But men do not like to believe that about themselves, nor about the nation to which they belong, nor even about the human

[7] Bagehot, W., "Physics and politics," 1902, ch. V.

race. They like to think that a people chooses its paths and policies, and consciously and purposefully advances toward some selected end. They make much of what might be called a rational selection by a people between codes and policies presented to them for adjudication. The country is figured as thinking things out for the country's welfare, as sifting evidence and being intellectually persuaded as to this and that. It seems to be assumed that "the people" can think in terms of a nation and will form a public opinion that operates as intelligent self-direction.

Most of this sort of contention is myth-making, like the philosopher's picture of the "noble savage"—he never having seen one. Perhaps some rare statesman may rise to the power of thinking in terms of high generality; but it is at his peril, at least during his lifetime, that he tries to realize those thoughts. Lofty talk is appreciated, but action on the basis of wide generalization is repellent, as "unpractical" or "idealistic." Long after his death, such a statesman may get a statue; but that will be in consequence of the verdict of history, arrived at when the heat and passion have died down.

What moves men—the masses of men, whose numbers, social bulk, and formidable inertia are commonly left out of adequate account by theorists—is not thought, but emotion. And what sets emotion going is interest. And the circle of interest is, for most men, very narrow and very closely drawn around one's self. What sets the revolutions in motion, with the result of drastic selection in the codes, is not the cerebration of anyone over great issues, but the unendurable discomfort and awakened emotions of the masses. Their interests have been so outraged that anything seems likely to be better than the present. Hence a passion to overturn things and take a new start. It is the opportunity of the agitator, for misery is indefinitely credulous—hopelessly thoughtless—never intellectual and analytical. The "quadrennial revolution" or "bi-

ennial revolution," as an American election has been called, is a conflict of interests rather than one of state-craft: debtors *versus* creditors, ins *versus* outs. How can the masses pass intelligently on an issue like that of the tariff or the gold standard, when it takes a super-expert to understand them? Add to this the thick-and-thin adherence to party, the shufflings and compromises of leaders, the personal animosities, the campaign of emotional propaganda, and what becomes of the election as an agency of rational selection between proposed adjustments to the nation's life-conditions?

The fact is that there are a number of phases of any nation's code which are beyond the pale even of criticism; reason is not invited to scrutinize them, and if it attempts to do so, it is roughly bidden to desist. There are plenty of details in any code of mores which we cling to with as deep emotion as the savage shows for his medicine-bag, and which it would be sacrilege to submit to the searchings of reason. One cannot expect rational selection in the field of religion, nor of marriage and the family. The Mohammedan is not ready to analyze the merits and demerits of Islam, and abide by the results; nor the monogamist to make a cold-blooded study of the merits and demerits of pair-marriage. The people love one public figure, and overlook or smile at his defects; they hate another, and jeer at or misrepresent his virtues. Where feeling is strong, reason counts for little. It is cynically said that the chief function of the human mind is to think up reasons for doing what one wants to do, or to find good reasons for having done what one wanted to do.

These considerations may seem dismal to one who would like to believe that men think out society's destiny; but they do not seem discouraging to one who believes that the operation of the big, impersonal, automatically working forces always gets truer results than do the feeble powers of the human mind; that natural law is far more reliable than men's enact-

ments. Most men would make hopeless errors in the piloting of society. But they are generally pretty clear as to their immediate personal interests. If these interests are in the hands of the interested—if people are minding their own business—they are in the custody of precisely those who are best capable of handling them. People with common interests make common cause and form competing groups; and out of the competition of such groups selection affecting the destiny of the whole society is bound to come.

It is bound also, in the long run, to result in adjustment. It is by such automatic, unplanned selection that all that we call improvement in adjustment has come to pass. The big man is the individual who correctly diagnoses the trend of events and rides in upon a wave of public opinion formed under a variety of motives which are often totally irrelevant to the results attained. That a wave of public opinion shall be raised, it is necessary that there shall exist a popular discontent, or irritability that can be excited to express itself in action, and, given this condition, it is necessary to fit the appeal to the variety of interests involved—interests which will be found to be for the most part personal, local, and but slightly or not at all relevant to any central principles. Masses of men do not look critically into the rational merits of a case. In this country, for instance, it is generally assumed that discomfort is due to governmental inefficiency or worse, and therefore hard times are likely to result in the upset of an administration. The process by *ex parte* conviction and snap-judgment is natural enough, and is shocking to those only who revolt at seeing things as they are.

It will be a long time before public opinion will form itself deliberately upon thought in terms of society. Few can envisage so large and complex a thing. The eugenists seem to hope that people will come to mate or refrain from mating with the interests of future generations in mind; but only the

very enlightened few can be imagined as so doing. Human beings act upon interest as they see it; and interests are bound, for the masses of mankind (who must do the selecting that is done), to be narrowly circumscribed.

That this is a counsel of despair is nothing against it, if it is true. But it is not such a counsel. Societal evolution is a vast process, where the forces are massive and act with unhurried deliberation, endlessly interlocking, within a spacious field. There are dim ages of the process behind us, and ages untold yet to come. Selection occurs at every stage, and is but an episode along the course.

How then can men do anything, if all is determined by such cosmic power? Why struggle?. Well, man can do something with gravitation, with the expansive power of steam, with the germ-plasm stream, although he can control the processes themselves in no degree. He can move things about, into the path or out of the path of natural forces. He can fix the mill-wheel beneath the falling water. He can place the cylinder in the way of the steam. He can isolate or bring together the sexes of animals. This has been done so successfully for man's interests and welfare that man has conceived the idea that he is master of nature. But what he has done is to learn nature's ways and adapt his action to them. At a pinch he is nature's plaything and victim: the earth shakes a little, and his great works collapse; the volcano spills a little gas over its crater-rim upon a town, and the lords of nature lay them down and are still.

It is not otherwise with the elemental forces of the societal realm. They cannot be mastered; they must be studied and known and adjusted to, as a condition of societal well-being. The efforts of many a would-be benefactor and uplifter of the race are sterile or even harmful because he is trying to do what he would realize, if he knew what a society is, and what can and cannot be done with it, to be out of the question.

Every one knows that water will not run uphill; yet in the societal realm there have been plenty of well-meaning people, through the ages, who have worn out and wasted their lives in unhappiness, trying ineffectually to overcome a societal tendency and law which are equally inevitable. If an ignoramus plays about in a chemical laboratory, we keep our distance, for we expect trouble as a result of ignorance of chemical substances and laws. Knowledge of the experimenter's good intentions or orthodoxy does not reassure us at all. But we easily permit the uninformed meddler to prowl about the structure of society, poking and tinkering, apparently in the belief that, provided his intentions are good, nothing but human weal can result. We are bound to learn, sometime, that powerful forces are at work within the societal range, and that ignorant tampering is even more dangerous here than elsewhere because so many more people have to endure the consequences. Then we shall want more knowledge of these forces, that we may adjust to them.

Intelligent adjustment to the known inevitable is as rare on earth as automatic adjustment to the unknown inevitable is common. But the former is an abridged and less painful process. Adaptation is sure, because it is the condition of comfort and of life itself. Adaptability is that which hurries and eases the process. Of all earthly things that which possesses the supreme capacity for swift adaptation is the human mind. But that capacity is undeveloped, fettered in its action by pseudo-knowledge, bias, caprice, and sentimentality—except where tests and verification are immediate and conclusive, and where, therefore, knowledge is almost automatically acquired. Nowhere is real knowledge and science so little in intelligent demand as in the societal realm, for the latter is self-sown to whims and dreams of all varieties. It is thought that man can here have his own will; here, at last and at least, he is lord. He senses no elemental powers in the field. Here, of all places,

he needs but to plan and "create"; pass resolutions and regulations; think out utopias in bed and then rise and gird himself to their realization; abolish property, or the family, or government, or religion. Naturally he is taken by the theory that societal evolution is by individual purposeful action. Naturally he regards insistence upon the control exerted by spontaneous, automatic, and impersonal forces as an assault upon his "free will."

Sometimes, in a crisis, the verities stand forth and enforce to themselves an attention which they do not get in ordinary times. Many people have been for some time perplexed and in weak despair because their comfortable little formulas have cracked and broken under the weight of explanation laid upon them. Perhaps it is a favorable occasion to offer the contention that "social theory" is not wholly academic after all.

CHAPTER VI

THE TREND OF EVOLUTION[1]

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If in the manner of the Olympian gods we mortals could have viewed from some exalted place the grandest drama which has ever unfolded itself on this planet, namely, the origin and evolution of life, and if in the manner of the modern "movie" we could have seen this drama speeded up so as to bring the whole of it within the sight and experience of any one person, with what surprise should we have watched the marvelous appearances and transformations which at almost every step have marked its progress, and how utterly impossible it would have been to have predicted its future course or from its small and weak beginnings to have foreseen its magnificent developments, its tragic failures, its stupendous successes! What merely human intellect could have foreseen in those earliest protoplasmic particles "the promise and potency of all life," the million species of animals and plants, the monsters of the deep, the giant saurians, the mighty beasts, and finally man? Who could have predicted the marvelous adaptations for nutrition, locomotion, offense and defense, reproduction, sensation, and coördination? Who could have foretold from the earliest reactions of this primeval protoplasm the complicated and subtle behavior of plants and animals and men? Who could have foreseen in these reactions

[1] A portion of this chapter appeared in the *Yale Review* for July, 1922.

the development of an intellect capable of studying or appreciating, even to the extent of wondering at, this marvelous drama? Who could have foreseen in the earliest stages of the association and dependence of individuals the future societies of ants or bees or men? Indeed, who at any stage in this greatest drama of all time could have predicted the next scene, much less the final ending?

If to human intellect every former stage in this process would have been unpredictable, what likelihood is there that future stages may be predicted? Surely these considerations should weigh heavily with anyone who attempts to forecast even the next step in evolution and they should make it plain that the final outcome is almost as completely hidden from us as it was from the original amœba.

But in evolution, as in the succession of generations of individuals, there have been cycles which have repeated again and again particular principles, problems, and solutions, just as one theme may form the groundwork of a great symphony. All that has been said of the impossibility of predicting the course and outcome of evolution could have been said with equal accuracy of the development of an individual. Who that had not before witnessed the process of development could possibly see in an egg the promise and potency of all that will develop out of it,—the complicated body, the remarkable instincts, the emotions, intelligence, and consciousness,—in short, the personality of a human being? But, owing to the fact that this process of development repeats itself again and again with slight variations, it is possible to predict its general course and outcome though not always its particular details. And so in the case of evolution we find that certain principles and cycles repeat themselves again and again and they make it possible to foresee at least dimly and in ghostly outline the mighty shadows and shapes of the future.

It is in this spirit only and not with the vain imagining that

any human being can predict particular events that depend upon so many factors as are involved in the development of an individual or the evolution of a race, that I venture to direct your attention to the trend of human evolution.

Causes and Directions of Past Evolution

And first it is necessary to consider the chief causes of evolution in the past and the most important paths which it has followed, for there is no way of looking into the future except by the light of the past. Unfortunately our knowledge of the causes of evolution is not very complete, but the majority of biologists agree that inherited variations, or mutations, constitute the building materials of evolution, while natural selection, or the elimination of the unfit, is the workman or architect that selects or rejects these materials.

Inheritance and Variation. In order to be of any evolutionary value a variation must be inherited. Thousands of variations occur in organisms which are not inherited; they come with changes in food, climate, use or disuse or other conditions of environment and when these conditions change they disappear. These environmental variations are known as "fluctuations"; they represent changes in development rather than in heredity, modifications of the developed organism rather than of the germ-plasm. On the other hand, inherited variations are caused by changes in the germ-plasm itself. These changes may be of two kinds, (1) those which are due to new combinations or recombinations of old inheritance factors, or what is known as "Mendelism," and (2) those which are caused by sudden alterations in the individual factors or genes, such transformations being known as "mutations."

Formerly these three types of variation, namely, fluctuations, Mendelian combinations, and mutations, were not clearly distinguished, and Darwin assumed that all kinds of variation

might be of evolutionary value. We now know that fluctuations have no evolutionary value; Mendelian combinations probably play a secondary part in supplying the materials of evolution, though this part is not negligible; mutations, on the other hand, are the fundamental and initial steps in evolution. Fluctuations and new Mendelian combinations occur in countless numbers; indeed, they may be said to be universally present among organisms; mutations, on the contrary, are relatively rare. Nevertheless, they are by no means uncommon; during the past dozen years Professor T. H. Morgan and his associates have found and studied about four hundred mutations in the pomace fly, Drosophila; few of these were beneficial changes and almost all of them would have disappeared in a state of nature, but this probably indicates that natural species and varieties are the products of very severe selection, that thousands of mutations have been eliminated where one or a few survive. Many of our numerous breeds of domestic animals and cultivated plants have appeared as mutations, and while we cannot assume that all that have been preserved are intrinsically useful nor that all useful mutations have been preserved, the great number of breeds that have arisen among domestic animals and cultivated plants indicates that useful mutations occur in sufficient numbers to furnish the materials for evolution.

There can be no question that the same fundamental principles are involved in the evolution of man as in the evolution of any other organism. Inheritance and variation, fluctuations, Mendelian combinations, and mutations occur in the human race, just as in plants and animals. Furthermore, there is good evidence that this is true not merely of the body but also of the mind and society of man. The fundamental principles in all kinds of evolution are similar and if mutations and new Mendelian combinations, but not fluctuations, are the materials of physical evolution, and natural selection is the

builder, it is altogether probable that the same is true of intellectual and social evolution.

Mutations and Their Causes. Regarding the causes of mutations we know very little, but it seems logically necessary to assume that these causes are both intrinsic in the germ-plasm and extrinsic in the environment; or, in the language of Darwin, "Although every variation is either directly or indirectly caused by some change in the surrounding conditions, we must never forget that the nature of the organization acted upon essentially governs the results." The same outer conditions acting upon different species or individuals produce different results and the possibilities of evolution are always limited by the organization of the germ-plasm. Some conceivable mutations do not and cannot appear because of these limitations. "Whales never produce feathers, nor birds whalebone," said Huxley; and probably no one ever really saw a green horse or a purple cow. But, although mutations cannot take place in all conceivable directions, there is no justification, in recent experimental work, for extreme views of orthogenesis which regard mutations as taking place in only a single direction. Furthermore, an extensive study of mutations shows that they are as frequently injurious as beneficial; indeed they are rarely as well fitted for existence as the stock from which they come.

It is highly probable that mutations take place in response to changes in environment, but it is necessary to remember that the environment of the germ-plasm is not merely the outer world but also the inner environment of the body organs and fluids and cells, and the innermost environment of the cytoplasmic and nuclear substances which surround the inheritance factors or genes.

Inheritance of Acquired Characters. But in spite of the fact that mutations probably occur in response to changes in the inner or outer environment, it is practically certain that modifications or fluctuations of developed organisms are not trans-

mitted to the germ cells so as to reappear in the next generation. In short, there is no inheritance of specific characters acquired by the soma. Evolutionary changes do not first occur in developed organisms and then by some mysterious process get into the germ-plasm, but evolution consists in an evolution of germ-plasm which then manifests itself in the developed organism.

It is known as a matter of fact that acquired somatic characters are not usually, if ever, inherited. Environment, training, education, may greatly modify glands, muscles, nerves, and brains, but they do not change the germ-plasm so as to produce these identical modifications in the next generation. In a few instances it seems probable that chemical substances in the bodies of parents, such as hormones, or anti-bodies, may influence the germ cells or developing embryos so as to produce bodily changes in offspring similar to those in the parents, but in general it may be said that there is no satisfactory evidence that the specific modifications of development, due to particular conditions of life, enter into the germ-plasm and appear again in the next generation, in the absence of the environment which first called them forth. In short, the effects on development of environment, training, and education are not inherited through the germ cells and the hope of permanently improving the human race, or any other species, in this manner can only lead to disappointment and failure.

Social Inheritance. At the same time it must be remembered that man transmits to his descendants not only a particular germ-plasm which determines bodily qualities and mental capacities, but he also hands down through language, education, and customs, his own acquirements, experiences, and possessions as well as those of former generations. This has been called "social inheritance" to distinguish it from "germinal inheritance"; it is inheritance in the legal rather than in the biological sense. In this sense we have inherited from our

ancestors language, literature, science, property, customs, institutions. These are no part of our germ-plasm, nor even of our blood and brain, but rather of our environment. Because of this social inheritance society may advance from age to age, each generation starting where the preceding one ended, as in a relay race,—whereas in our germinal inheritance each generation begins where the previous one began, namely from an egg cell, and the whole course of development must be repeated in each generation. Civilization is the result of the accumulations of social inheritance, and the future progress of society must depend largely upon this capacity of profiting by the experiences of former generations.

Natural Selection. If mutations are the materials, natural selection is the architect and director of evolution, for although it does not originate fitness it continually eliminates the unfit and in the long run preserves only the fit. In certain quarters it has been fashionable of late to decry the importance of natural selection, but more and more, biologists are coming to recognize that it is the most important directing and perfecting factor in evolution.

Natural selection in its widest meaning involves not merely the overproduction of individuals and the consequent struggle for existence with elimination of the unfit, as Darwin formulated it, but it also includes the overproduction of many vital activities, such as motions and reactions, with the elimination of the unfit, as in the process known as "trial and error." Thus useful behavior is the residue left after useless responses are eliminated, and it is not necessary to hold with Darwin that fitness is always the result of the elimination of unfit *persons*. It is often the result of the elimination of unfit *reactions*. In short, natural selection is not only personal but also intra-personal.

Furthermore there are many kinds of fitness not only for different environments but also for different organisms and

lines of evolution. Physical, intellectual, and social fitness are very different things, and it is possible to have any one of these without the other two. The past evolution of the human race has been guided by the elimination of the unfit, whether physical, intellectual, or social, and the future progress of the race must depend on this same process.

The Paths of Progress. Even a cursory study of the living world would justify the opinion that evolution has proceeded in all possible directions; crab-like it moves forward, backward, and sidewise. This is especially true of the minor stages of evolution represented by mutations, for these apparently occur in all directions without reference to their utility or inutility; however, in order to survive and become established, a mutation must run the gauntlet of natural selection and injurious mutations are eliminated. Much more is this true of species and larger groups which have had a longer and more severe trial than mutations and are consequently peculiarly adapted to their environments. In particular instances simplification and degeneration have occurred but in the main evolution has been progressive, that is, it is marked by increasing complexity of structures, functions, and adaptations, just as development from the egg to the adult is generally progressive, though in some instances and stages it is retrogressive. Particularly when one surveys the whole course of phylogeny or ontogeny it is evident that there has been progress from relative simplicity to complexity.

Definition of Progress. The very word "progress" calls forth a reaction from some people not unlike their response during the war to the word *Kultur*. A few persons seem to deny the existence of any such thing as progress, while others insist that it is too indefinite to admit of any formulation. Undoubtedly progress may occur in many different directions and toward different goals, but everywhere and always in the living world, it has certain fundamental characteristics. As is

generally true in complex phenomena it is best defined in terms of causes rather than of results.

Everywhere in the living world, progress is brought about by increasing specialization and coöperation, or, in the language of biology, by increasing differentiation and integration. Whether it be the development of an egg into an adult, the evolution of primitive animals and plants into their more complex descendants, or the development and evolution of the body, mind, and society of man, progress everywhere is caused by increasing specialization and coöperation. In the development of an egg, which is the symbol and epitome of all progress, there is segregation of different structures and functions in different cells and parts of the body, that is, there is morphological division of substance and physiological division of labor, and at the same time there is increasing perfection of functions and adaptations. In the evolution of limbs or eyes or brains there is a similar increase in the complexity of differentiation and integration. In both the ontogenetic and the phylogenetic development of intellect and of society, there is increasing complexity and perfection of function and adaptation. All kinds of progress, whether of body, mind, society, art, industry, or science, are marked by increasing specialization and coöperation. As thus defined, progress may lead in different directions to very different ends, as is shown in the various types of locomotion, offense and defense, sense organs, nervous systems, etc., found in the animal kingdom. In man it has led to increased cranial and intellectual capacity, increased control over environment and greater freedom, increased size and complexity of social units, etc. But progress in each of these many paths is caused by increasing complexity and perfection of specialization and coöperation.

Limits of Progress. Biological progress, however, always has its limits; sooner or later differentiation reaches a stage beyond which it cannot go without destroying the internal

balance, or integration, and the adaptability to external conditions. Furthermore, in the higher types of organization the mutual dependence of parts becomes so great that when one of these is injured or breaks down it carries with it to destruction the entire organism. As Professor Minot used to say, "Death is the price we pay for our differentiation." Germ cells and embryonic cells are potentially immortal, but tissue cells are not self-sustaining and the more highly they are differentiated the greater is their dependence and the more certain is their ultimate death.

The record of the rocks is full of instances in which groups of organisms have progressed to greater and greater complexity and have then become extinct. The roads of progress are strewn with the remains of creatures fearfully and wonderfully specialized, but which were unable to preserve internal balance or to adapt themselves to new environments and which therefore perished. Indeed, in practically every instance the road of ever increasing progress ends in extinction. But just as in the succession of generations highly differentiated cells and individuals die and new generations arise from relatively undifferentiated eggs, so when highly differentiated species become extinct new lines of progress start from generalized rather than from highly specialized types.

It is of course conceivable that differentiation might go on indefinitely in any line, the elephant might get a longer trunk, the giraffe a longer neck, and man a larger and larger brain, but while such things are conceivable they are not practicable for the reasons named. In any line of evolution progress is most rapid at first and then it gradually slows down until it stops, and in every well-tried path of evolution, progress has practically come to an end; further progress, if it occurs, must be in new lines and from relatively undifferentiated stock.

Progressive Evolution of Man. There have been three main lines of human evolution,—physical, intellectual, social,—

and it is generally assumed that in each of these lines we may look forward to endless progress. The infinite perfectability of man is a fundamental article of faith with many people, and yet all biological evidence indicates that it is not supported by fact. Not only the history of other organisms but also that of man himself indicates that progress in any particular line is limited.

In bodily evolution man has made no very marked progress during the last twenty thousand years at least. Undoubtedly there have been minor changes in the human body, probably an increasing resistance to certain diseases due to the elimination of those persons who were more susceptible, as well as certain degenerative changes in sense organs, hair, teeth, and toes; but such changes are insignificant when compared with those which marked the transition from pre-human ancestors to man, or even those changes which brought about the differentiation of the primary races of mankind. The physical evolution of man has slowed down almost to a standstill, and if it is to go forward again it will probably be in new lines and in response to new and very different environmental conditions.

The opinion is widely held that intellectual evolution is advancing rapidly and in justification of this belief is instanced our increasing knowledge of the world and of man. But it is necessary to distinguish between intellect and knowledge, between the capacity for knowing and things known. Undoubtedly we know many more things than the ancients or even than our own parents, but has there been any increase in intellect comparable with the increase in knowledge which has marked the last few centuries? On the contrary, those who have devoted much attention to this subject are of the opinion that no modern race is intellectually equal to the ancient Greek race. Not only did this race produce a larger number of illustrious men than has any other race during an equal period of

time but the general intelligence of the citizens was probably higher than in any modern nation.

Undoubtedly popular education brings to light many persons of marked intellectual capacity who in former years might have remained "mute, inglorious Miltons"; there are many more opportunities to-day for discovering the inherited capacities of men than there were in ancient times, but anyone who thinks that intellectual capacity is undergoing rapid evolution needs to consider seriously the widespread emotionalism, irrationalism, and superstition of this twentieth century of enlightenment as compared with the golden age of Greece in the fourth or fifth century B. C. Indeed, since the times of the Crô-Magnon race, probably twenty thousand years ago, there has been no marked increase in man's cranial capacity, and probably little or no increase in his inherent intellectual ability. There are better opportunities to-day than ever before for the development of the individual but the intellectual evolution of the race, no less than the physical, has slowed down until it has practically stopped.

In human society, however, tremendous changes are taking place and many of these are in the direction of progress. The great advances in our knowledge of and control over nature, which are such a distinctive feature of our present civilization, are the results of coöperative effort. The developments of science, literature, and art, of agriculture, industry, and commerce, of education, government, and religion, are the products of increased specialization and coöperation of society. The fact that social change is going on so much more rapidly than either physical or mental evolution is due to the fact that past experiences and acquired characters are handed down through "social inheritance," but not through the germ-plasm. If we consider those social changes only which are due to modifications of the germ-plasm, such as inherited instincts and capacities, we find that evolution is probably no more rapid in

society than in the case of the body or mind of man. Within historic times the social instincts of men have not changed more fundamentally than their intellectual capacities or their germ-plasm.

Unlike any other form of evolution, the rapid changes which are taking place in human society are not due to changes in germ-plasm, nor even to changes in the developed individual, but merely to changes in environment. They are not even skin-deep, they are only clothes-deep. It may be questioned whether these changes are really evolutionary at all since they do not involve changes in germinal inheritance, intellectual capacity, or social instincts, but are merely the accumulation of experiences from generation to generation, as an individual accumulates knowledge from year to year. Indeed, the progress of human society is much more like the development of an individual than it is like the evolution of a species.

But whether we regard social development as a form of phylogeny or of ontogeny, as a result of inheritance or of environment, we cannot fail to see that it is going forward at a rapid rate and that it is fraught with the most stupendous possibilities for the future. The only great progress which the human race has made during the past twenty thousand years has been social, and so far as we can now see into the future the progressive evolution of mankind must depend to a great extent upon society. It is particularly in the field of discovery and invention that progress has been most notable. Nothing could more strikingly illustrate this than the comparison of the state of the world one hundred years ago with that of to-day. Whole regions of the universe have been explored, the very existence of which was not dreamed of a generation ago. Inventions which would seem incredible or magical were they not so common are everyday conveniences. Diseases and epidemics which were once regarded as the direct acts of an inscrutable Providence or of unscrupulous demons are now

prevented or controlled. All this notable progress in the conquest of nature is the result of coöperative effort. No one person, however great his contributions, could have made any important advance alone and unaided. Every discovery is based upon many others which have gone before, and all civilized countries and ages have contributed to the advancement of knowledge. In short, progress during historic times has not been in the individual but in the association of individuals, not in the inherited capacities of persons but in the organization of society.

Not only the direction of social evolution, but also the future evolution of the body and mind of man will be determined to a great extent by society. Progress through natural selection is exceedingly slow and wasteful, intelligence is a great time-saver as contrasted with "trial and error," and intelligent artificial selection affords the most rapid and satisfactory means for the improvement of the human race. There is no doubt that mankind could, if it would, breed a more healthy, more intelligent, more moral type than the general average of the existing race. By means of artificial selection, requiring no more intelligence than that which is now used in the breeding of domestic animals, weakness of body, of mind, and of social instincts could be largely eliminated, and the average of the race could be raised to a level more nearly that of the best existing individuals. To a large extent mankind will determine its own destiny on this planet. Whether it has wit enough to save itself from the dangers which now threaten is a serious question.

Present Conditions and Tendencies

Our watchers on Olympus would see in present conditions and tendencies of the human race some promising prospects but much cause for grave concern. Perhaps the conditions which would cause most anxiety are the nullification or com-

plete reversal by man of some of the most important principles which have guided evolution in the past. For the first time in the history of life upon the earth, a single species now has the power of controlling to a large extent its own evolution, and it has begun by radically changing some of the conditions of progress which have prevailed hitherto. A large part of the human race is now engaged in the most stupendous and dangerous experimentation upon itself; without any adequate knowledge of the mechanism of evolution it has begun to tinker with that mechanism, throwing certain parts out of gear, destroying others, and in general paying little or no attention to the results.

Decreasing Influence of Natural Selection. In spite of some notable exceptions, the leading biologists of the world agree that natural selection has been the most important guiding and perfecting principle in past evolution, and on the whole it has made for progress. At every step in the past course of evolution it has sifted the unfit from the fit, and while it has not originated fitness, it has preserved it, and in general it has directed evolution into paths of progress by closing up other paths. Those whose only conception of natural selection is that of a life and death struggle between individuals of the same species may well rejoice that mankind is to a certain extent freed from this struggle, and that in human society coöperation is becoming a more important means of progress than competition. But natural selection in its widest sense means the elimination of the unfit, whether these are reactions, instincts, customs, persons, races, or species; and if in human society coöperation is more beneficial than competition, cooperation rather than competition will be favored by natural selection. And in similar manner if intelligence is more beneficial than brute strength or cunning or instinct, intelligence will be favored. In short, there are many kinds of fitness in different lines, and in the case of man, if natural selection were

not interfered with, it would lead to the partial or complete elimination not only of the physically unfit but also of those who are mentally and socially unfit.

Of course man cannot wholly eradicate natural selection from human life; the most monstrous forms cannot possibly be saved and the more abnormal they are the earlier they die; the seriously defective rarely come to maturity or are capable of reproduction and even those that survive and reproduce are usually handicapped at every stage. Natural selection remains and will probably ever remain an important factor in human evolution, but just as far as is possible it is being minimized or set aside in civilized states. In the finest fervor of altruism and with the most extraordinary expenditure of money and effort civilized society manages to save many of those who are feeble in mind and body as well as criminals and enemies of society. And no doubt much of good is gained in this way, for not only are great minds and souls sometimes lodged in frail bodies but it is probably more valuable to the race to preserve a spirit of altruism and social justice than it is to rid society of its degenerates by ruthless methods. Nevertheless, neither justice nor altruism requires that such persons be permitted to propagate their kind; lasting progress cannot be based upon a one-sided development of body or mind; ideally, as well as biologically, life and progress are balanced as it were between many different forces, principles, and ends, and neither physical, intellectual, nor social developments should go so far as to destroy either of the others.

Galton says, "Our human stock is far more weakly through congenital imperfection than that of any other species of animals, whether wild or domestic." It cannot be doubted that this greater weakness and imperfection is due to failure to eliminate the unfit, but there is no clear evidence as to whether congenital physical degeneracy is increasing or decreasing at the present time. Athletics, physical education, medicine, and

sanitation have made great advances in recent years and this has had a beneficial influence on the health and vigor of this generation, but there is no satisfactory evidence that these effects are inherited. The average length of life has been increased, chiefly by saving the babies, but the maximum length of life has not been raised; men live no longer now than in the time of Methuselah, and since longevity is hereditary, it may well be that the artificial prolongation of the lives of those who are hereditarily weak and short-lived may actually reduce the natural longevity of the race as a whole.

Mental and moral degeneracy runs in families, as is proved by such cases as the "Jukes," "Kalikaks," "Zeros," "Nams," "Ishmaels," etc., but social selection against such groups is pretty severe and it does not seem probable that extreme defectives of this class are increasing very rapidly. Inmates of custodial institutions are usually prevented from having offspring and they do not greatly threaten racial standards; the greatest danger comes from somewhat less defective individuals who are at large and are free to have as many children as they can.

Retrogressive Selection of Civilization. Much worse than this partial failure of natural selection is the retrogressive selection of civilization. If society had deliberately set about the propagation of the unfit it could hardly have devised more effective means than many of those which are now in vogue. Frequent wars have taken the best blood of the nations, and while casualties in modern battle are more or less indiscriminate, soldiers represent a selected group; those who go to war are usually the young, the strong, the capable, while the weak, incompetent, and degenerate are left behind as unfit for military service. Furthermore, these casualties must be doubled when their influence on the race is considered, for in general every man killed leaves one woman unmated for life. As a result of the last war millions of women can never marry

or have children. Among these are some of the best human stock the world possesses,—and thus the race is made poorer for many generations to come. Enforced celibacy in many religious orders and societies of scholars has led to the extinction of some of the world's most gifted lines. The present customs of mate selection condemn many of the finest women in the world to spinsterhood, while the feather-brained and sexually-daring "flappers" readily find mates. On the other hand, personal ambition and selfishness, the prevalence of prostitution and illicit sexual relations, the fear of misalliances, divorce, and alimony are potent causes of bachelorhood. In both cases the results are that many of the best human lines are wiped out. Galton has shown that on the average people who marry at twenty-two will leave twice as many descendants at the end of a century as those who marry at thirty-three and in a few generations they will actually possess the earth. And yet the increasing time required for education, as well as more luxurious standards of living, have made early marriages almost impossible among professional and business classes, with whom the most vigorous and fertile years of the reproductive period are years of sterility. Finally, luxury, soft living, and selfishness have made children unwelcome among many married people who have shown qualities of success in life and whose hereditary traits are above the average. Under such conditions the general average of intelligence and social fitness in the race as a whole must inevitably decline.

There is an evident tendency to assortative mating in modern society due not merely to similarity of social status and ideals but also to the more potent factor of propinquity. Generally men and women representing the extremes of the social or intellectual scale do not marry and it has been claimed that owing to this fact there is a constant tendency for society to be split up into hereditary classes. Some authors maintain that the more intelligent and the less intelligent elements of

society are separating more and more widely, that the successful are being split off from the unsuccessful, and that, in general, human society is differentiating into hereditary classes owing to the tendency of like to mate with like. However, when one considers the world as a whole, rather than a few small social groups, it is plain that any such tendency to form hereditary classes is more than overbalanced by other factors. The permanent stratification of society is prevented by the rising of genius from the lower levels and the sinking of mediocrity from the higher, by the boiling of the social melting pot, by new mutations and Mendelian combinations, all of which contribute to cast down the mighty from their seats and to exalt those of low degree. In the past history of mankind there have been many attempts to establish hereditary classes; where now are the castes of rulers and slaves, statesmen and soldiers, scholars and priests, craftsmen and farmers, of ancient Egypt, Assyria, Greece, and Rome, or even of medieval Europe? The instincts of the race as a whole are against the establishment of such hereditary classes and in favor of democratic equality of opportunity, with social position dependent upon individual merit rather than upon family name or class privilege, and these instincts are probably sound both socially and biologically.

Some advocates of eugenics have dreamed of the establishment of an intellectual aristocracy by the segregation and intermarriage of the most highly gifted members of society, such as the prize scholars in colleges and universities. No doubt this could be accomplished if some power could bring about such segregation and propagation, but unless these prize scholars combined many excellent physical and social qualities as well as mental ones such segregation would probably lead to very unsatisfactory results. It would seem to be better for prize scholars to marry prize athletes and thus preserve the

general all-round excellence of the race, rather than to attempt to develop an intellectual or social aristocracy.

Decreasing Birth-rate of Intellectual Classes. There is no doubt that intellectual ability is an inherited trait, in spite of the fact that great men have sometimes come from unknown ancestors and unknown men from great ancestors. Mental capacity probably depends upon a number of inheritance factors, and occasionally each of two mediocre parents may supply factors which the other lacks, thus giving rise to an excellent combination which is the initial step in the production of a great man; on the other hand, even superior parents may sometimes furnish a bad combination of inheritance factors, and the resulting child may be mediocre or inferior. But Galton has shown that in an equal number of distinguished and undistinguished families there are about five hundred times as many chances that a distinguished man will come from the former as from the latter. No doubt environment is an important factor in the development of intellect but the possibilities of such development are marked out in the germ-plasm. Superior intellectual ability is inherited no less than inferior ability, genius no less than feeble-mindedness.

It is therefore most important for the intellectual progress of the race that the more intelligent classes should increase and multiply and that the less intelligent should be relatively less fertile,—and yet the reverse of this is true. In spite of individual exceptions, the graduates of our colleges and universities probably represent on the whole the most intelligent portion of our population; they have been sifted out from their less gifted fellows by the grammar schools, high schools, and colleges, until, on the average, they are a very highly selected group. But this group is not perpetuating itself. The average number of children per graduate of Harvard and Yale for the years 1881-1890 was about 1.5. Up to the year 1901 the average per graduate of Vassar and Bryn Mawr was about

.8, of Mt. Holyoke about .7, and of Smith College a little less than .6. In other words, as Cattell says, the average graduate of Harvard or Yale is the father of three-fourths of a son and the average graduate of the women's colleges named is the mother of rather less than one half of a daughter. The birth-rate among the members of the honor society, Phi Beta Kappa, is much lower than that of the average graduates, and in general it may be said that the higher the intellectual attainments, the lower is the average birth-rate. This is true not only of college graduates but of the more intelligent people generally. Among American men of science, Cattell finds that the birth-rate has decreased in a single generation from 4.66 per family to 2.22. Since in the general population it takes an average of three or more children per family to preserve present numbers, it will be seen that these highly selected lines are dying out. And as rapidly as others of superior intelligence rise out of the general population they also become relatively infertile. Thus the intellectual cream of the race is continually skimmed off, and it is a question how long it will continue to rise.

There is great enthusiasm to-day among certain people, who are generally childless, for small families; the race is to be regenerated by birth control. But this "reform" begins among those who, because of good hereditary traits, should have large families. If only those who should not have children were to practice birth control, it would be a blessing to mankind, but there can be no doubt that thus far it has greatly reduced the number of children among the intelligent and prudent classes, without influencing to any extent the birth-rate among the unintelligent and imprudent. Whether this result will be reversed in the future no one can predict. Alexander Graham Bell believes that it will, in time, benefit the race by eliminating those among the intelligent classes who are lacking in parental instincts. Irving Fisher says there are three possibilities in

birth control: (1) it may cause depopulation and ultimately extinction of the human race; (2) it may reduce the reproduction of the prudent, intelligent, and ambitious, leaving the imprudent and unintelligent; (3) it may cut off the strain of the silly and selfish, the weak and inefficient. There is little if any likelihood that the first of these possibilities will ever be realized; depopulation may result in certain countries but it will never become universal through birth control. The second possibility is already an actuality so far as the reduction of the birth-rate among the most progressive people is concerned. It does not seem probable that the third possibility can greatly benefit the race before much damage has been done by the second. Of course if those who preach and practice birth control are, when measured by the highest standards, silly, selfish, weak, or inefficient to a greater degree than others, then, and then only, is it working for the betterment of the race. It seems incredible that people of good hereditary traits should think that they can improve the human breed by committing racial suicide. "There be those which have made themselves eunuchs for the kingdom of heaven's sake," but when before in the history of the world have sane men made themselves eunuchs in order to win the kingdom of the earth? Those feminists who declare that they would rather die than have children have made their choice between the only alternatives possible,—death to their lines and to their participation in the future of the race, or children.

But while the more progressive lines are, as a whole, dying out, the general population of this country and of the world is more than maintaining itself, and the less intelligent, independent, and aggressive portions of the population are probably increasing most rapidly of all. Thus the Scriptures are being fulfilled that "the meek shall inherit the earth." It is often said that a high birth-rate among the lower classes is

always offset by a high death-rate, but in civilized society this is by no means the case.

In a recent paper of great interest and importance, Pearl has shown that the "vital index," that is, the ratio of births to deaths within a given time, differs greatly in different elements of our population; it is lowest among the old American stock, and highest among the foreign-born population. In New England and in New York State, the native population of native-born parents produces only about .8 or .9 of a birth for each death, while in the country at large "the native population produces only a fraction over one baby for each death. In other words, the native population . . . is in about the same state as France before the war, and not in as vigorous a state as the French population is now." As contrasted with this, he says, "Generally speaking, the foreign population produces in this country approximately two babies for every death."

In so far as this foreign population is equal in quality to the native stock which it is replacing there is no cause for alarm in this, and except for sentimental regrets on the part of the old American stock, it may be welcomed as a rejuvenating factor, but if this foreign stock is in the main inferior in quality to that which it is replacing, then indeed is there cause for concern.

Race Differentiation vs. Race Amalgamation. Another important principle in past evolution which is being reversed in the case of man is that of racial isolation and differentiation. Since all types of mankind interbreed freely, it is evident that distinct races could not have been established and perpetuated except by the aid of isolation, chiefly geographical. On the whole, race differentiation has made for progress; it has led to the establishment of races peculiarly fitted to the environments in which they are found and it has favored the establishment of types superior in certain directions though they may be inferior in others.

However, with increasing means of communication, and as a result of migration and commercial relations, there is no longer complete geographical isolation of any people and the various races of mankind are being brought into closer and ever closer contact. Man is now engaged in undoing the work of hundreds of centuries; if in the beginning God "made of one blood all nations of men," it is evident that man is now making of all nations one blood. In the United States practically all the races of mankind are represented and a study of the census returns shows that all the European races in this country are being rapidly fused together. Pearl has recently shown that from "one fourth to one half as many children are produced in a given year from mixed matings (in which one partner is American) as from strictly American-born persons. Amalgamation of the immigrant elements into the previously existing complex is certainly going on apace."

The "typical American" is the product of the fusion of various European races and we, at least, believe that the results of such race mixtures are good. Even European races are rarely if ever pure, but represent mixtures of many different stocks. If "pure" English, Irish, Scotch, Dutch, German, Russian, French, Spanish, or Italian lines are traced back only a few generations they are found to include many foreign strains. The author of *Robinson Crusoe* wrote two centuries ago of the "True-born Englishman":

> These are the heroes that despise the Dutch,
> And rail at new-come foreigners so much;
> Forgetting that themselves are all derived
> From the most scoundrel race that ever lived;
> A horrid crowd of rambling thieves and drones
> Who ransacked kingdoms, and dispeopled towns;
> The Pict, and painted Briton, treach'rous Scot,
> By hunger, theft, and rapine, hither brought;

Norwegian pirates, buccaneering Danes,
Whose red-haired offspring everywhere remains;
Who, join'd with Norman French, compound the breed
From whence your "true-born Englishmen" proceed.

Even the primary races of mankind are rapidly fusing in many parts of the world. In the United States from 15 to 20 per cent of the total negro population of about 10,500,000 are mulattoes and these are increasing more rapidly than the pure blacks. In South American countries it has been estimated that there are about 26,000,000 whites, Indians, and negroes, and about 20,000,000 of mixed blood. In Australia and New Zealand, after only a little more than a century of contact with the whites, there are about as many "half castes" as full-blooded aborigines. Similar tendencies to amalgamation of the primary races are found in Mexico, the West Indies, Africa, Indo-China, the islands of the Pacific, and in other parts of the world. It is said that there are no cases in history where two races, however different, have for long occupied the same territory and yet have preserved their racial purity. Even the Jews, who are a peculiarly separate and distinct race, have received large admixtures of Gentile blood in every country in which they have lived. Fishberg says that in western Europe, America, and Australia from 25 to 50 per cent of all Jews who marry, marry non-Jews.

If this movement goes on, as we have every reason to expect that it will, it can only end in the more or less complete fusion of existing races, and it needs only the vision that can look ahead a few thousand years at most to see all races blended into a common stream. What the results of such fusion may be we can only guess, though its effects in ancient Egypt, Greece, Italy, and more recently in various countries of eastern Europe, the West Indies, Mexico, and South America are by no means reassuring. Hybrids are not necessarily in-

ferior, and they are sometimes superior to either of the parent races. Mendelian inheritance holds good in the crossing of human races as well as everywhere else and it leads to all kinds of combinations of the qualities of the parents. Accordingly some hybrids may be expected to show the bad qualities of both parent races while others show the good qualities of both, but it is practically certain that the general or average result of the crossing of a better and a poorer race is to strike a balance somewhere between the two.

If only good ore goes into the "melting pot" there is no cause to fear for the result; and if those hybrids which combine the good qualities of the parent races could be segregated and bred, a race superior to any existing human type could probably be established. This is just the method followed by breeders in the production of improved races of plants and animals, many of which are the products of deliberate hybridization. But the breeder ruthlessly eliminates inferior stock and breeds only from the best, and if by some similar process it were possible to eliminate from reproduction the inferior racial combinations and to perpetuate the best, we might expect to get from this great experiment in human hybridization a very superior breed of men combining the good qualities of all the constituent races. It seems very doubtful whether any such result as this will ever be attained, and in the absence of such selection and segregation the general result of race amalgamation must be an averaging of the qualities of the parent races.

The character of a composite race will depend not only upon the qualities but also upon the relative numbers of the races which enter into it, and the latter will depend upon the present numbers of existing races, their rate of increase, cultural development, and the habitable portions of the globe which they control. In all of these respects the white races hold the lead, followed in turn by the yellow, the brown, the black, and the red races, and it is evident that unless the white races destroy

one another, commit race suicide, or die at the top, they are destined to furnish the principal contribution to the future population of the globe.

The Limits of Population. Finally, the human population of the world is rapidly approaching its maximum—for while populations tend to increase continually the limits of the habitable globe remain fixed and the means of subsistence are subject to the law of diminishing returns. Pearl estimates that within 200 years the population of the United States will have reached its maximum of about 200,000,000. Alfred Marshall calculates that the population of the entire world will have reached its maximum of about 6,000,000,000 in 200 years. These estimates assume that increase of population and of means of subsistence will in the future conform to the same mathematical formulæ as hitherto,—an assumption that is probably justified. If these estimates are correct the grandchildren or great-grandchildren of persons now living may see the maximum population of this country, and perhaps of the world, attained. Even if by means of greatly improved agriculture or by revolutionary scientific discoveries this time should be doubled it would still be a relatively short period before the limits of the possible population of the globe would be reached. Thereafter the population will remain stationary, either through increase of the death-rate or decrease of the birth-rate. Under these conditions it is probable that both natural and artificial selection will be intensified. It is reasonable to expect that on the whole natural selection will make for progress and it does not seem probable that artificial means of limiting population will continue to cut off the better stocks and to favor the worse.

There is ground to hope, therefore, that in a crowded globe both natural and artificial selection will make for the improvement of the race, but such improvement is likely to be slow and painful. Natural selection, under various aspects, is still the

most potent factor in directing evolution though it is extremely slow in its action and excessively wasteful. There is reason to hope that in the near future intelligent human selection may coöperate with natural selection, thus rendering progress more rapid and more merciful. Certainly eugenical education should begin to bear fruit,—that is, more children of the better sort and fewer of the worse variety,—within the next generation. Unless it does we may be sure that the time will come when in a crowded globe natural selection will reassert itself and there will be a return to "nature's simple plan" of promoting fitness by the ruthless elimination of the unfit.

The Immediate and the Distant Future

The Immediate Future. In the midst of all these conditions and tendencies of the human race,—the decreasing influence of natural selection, the retrogressive selection of civilization, the decreasing birth-rate of the more intelligent classes, the increasing amalgamation of races, the rapid approach of the time when the earth will be fully populated and its natural resources exhausted or greatly diminished,—in the whirl of all these changes it does not seem probable that human evolution will long remain stationary. On the whole, it must be admitted that these tendencies do not point to racial progress, and some of them presage retrogression, degeneration, and decay unless they can be overcome.

There is much in the modern world that reminds one of the period of decline of former civilizations, and especially of Greece and Rome, and many persons have wondered whether our civilization is not traveling the downward road to a similar end. In both Greece and Rome the decline was preceded by a large amount of race mixture, and a decreasing birth-rate among the higher classes, while it remained relatively unchanged elsewhere. Momsen says that the decay of Rome was due mainly to "the difference between the fertility of the

higher and the poorer classes." Tenny Frank[2] concludes that in Nero's day, about 90 per cent of the plebeians on the streets of Rome had oriental blood, while the whole Empire was a "melting pot" in which the oriental was a large part of the ore:

> Race suicide curtailed the stock of the more sophisticated, the aristocracy, and the rich. Before our day, only at Greece and Rome was reproduction under rational control and there the race went under. Of forty-five patricians in Cæsar's day only one is represented by posterity when Hadrian came to power. Of the families of nearly four hundred senators recorded in 65 A. D. under Nero, all trace of a half is lost by Nerva's day, a generation later. The voluntary choice of childlessness accounts largely for the unparalleled condition—and is probably the most important phase of the whole question of the change of race.

A striking parallel to what is found in most of the civilized world to-day! Whatever may have been the causes of the decline of former civilizations, it is plain that there were left in other parts of the world strong human reserves that could carry forward the standard of civilization which was dropped by a dying race. But in a world where practically all western nations are suffering from this sickness of civilization, and in which racial amalgamation is fusing all into a common type, where are the reserves that can be rallied to the standard, if civilization should again decay? If history should repeat itself and the western nations should go down as did Greece and Rome, possibly Russia, or China, or Japan might take up the banner and civilization once more begin its westward march around the world.

But there is this important difference between present conditions and those of any former age,—our knowledge of and control over nature are vastly greater than ever before and the

[2] *American Historical Review*, 21, 1916.

means of increasing and diffusing knowledge were never so good as at present. If knowledge and education can save the race the prospect is promising, for they were never before so widespread; the possibilities of continued progress rest on education, eugenics, and enlightened effort.

Education is the first and most important step in combating these tendencies to racial decline. Assuming that the social instincts of the major portion of mankind are sound and that there is sufficient intelligence in the race at large to recognize the dangers that threaten, it ought to be possible by education to meet these dangers and overcome them. A more thorough and widespread knowledge of the nature of man and of the principles of heredity and development would lead to the elimination of many of these dangers, for in the main we have sinned through ignorance. Such knowledge would prevent the importation and propagation of physical, mental, and moral degenerates; it could prevent the amalgamation of better races and families with poorer ones; it should increase the number of good matings and of superior children; and it should make human life healthier, happier, more rational, and more efficient. Whatever good may come to the race through better legislation, sanitation, eugenics, or euthenics will be made possible by better education.

What part eugenics may play in the betterment of the human race cannot now be foreseen. There is no doubt that, by means of a thoroughgoing system of eugenics, feebleness of body and of mind could be largely reduced and the race as a whole made more healthful and intelligent; in short, the general average of the race could be raised more nearly to the level of the most perfect men and women of the past or present. It is doubtful whether eugenics can go farther than this and there is no probability that it can ever produce a race of supermen. Important as eugenics is in preventing racial degeneration it does not hold forth the hope of endless human

progress. For the present at least the most that it can do is to take the place of natural selection in limiting the propagation of the feeble-bodied and the feeble-minded and in favoring that of the strong and sane. This would at once preserve and perpetuate the best human lines and would in time raise the average of the race as a whole but probably it would not produce a new and better species of man. The eugenist can neither produce new mutations nor does he know what mutations or new combinations of characters will be most useful and most viable in future ages. If the fads and fancies of reformers could be established in the germ-plasm and all men could be made eugenically equal the whole race might come to a rapid end. It is probably fortunate that men are not charged with the duty of directing future evolution, and we can only hope that nature, which has directed progressive evolution from amœba to man, without human guidance, may work still greater wonders in future ages.

Finally the lesson of past evolution teaches that there can be no progress of any kind without struggle; in physical evolution progress has come through the struggle for existence and for more abundant life; in intellectual evolution, through strivings for freedom and enlightenment; in social evolution, through the victory of social instincts and ideals over anti-social ones. The improvement of the human race, if not the further evolution of man will depend in part upon enlightened human effort. To us it is given to coöperate in this greatest work of all time and to have a part in the triumphs of future ages, not merely by improving the conditions of individual life and development and education, but much more by improving the ideals of society and by breeding a better race of men who will "mold things nearer to the heart's desire."

The Distant Future. What the distant future may hold in store for the human race we can only guess. It may be that the entire race will become extinct and leave the dominance of

the earth to other living things. Although this has been the history of many dominant species in the past it does not seem probable that it will be the fate of man, for he is able to adapt himself to changed conditions, to modify his environment, and to control his destiny as no other creature that has ever lived on the earth has been able to do. If conditions of life should ever become so adverse that the entire human race should become extinct we may probably assume that all other higher animals would also perish.

It is possible that the entire race may suffer retrogressive evolution and return to a less highly organized condition. Many other types of animals have passed the climax of their evolution and have then declined and their degenerate representatives still survive. But in these cases other forms better fitted for survival have taken their places and progress has continued in other lines. Intellectual and social evolution has reached a climax in man and it has so greatly increased his control over himself and his environment that it seems scarcely possible that it will universally and permanently decline and be replaced by less adaptable and less efficient characters.

Perhaps in future ages the progressive evolution of man will continue, somewhere and somehow. If higher species of man evolve in the future it is not unlikely that this will occur, as in the past, in connection with great secular changes, over which man has no control, such as the rising and sinking of continents, the formation of deserts or mountains or oceans, or changes in climate comparable to the glacial and interglacial epochs, during which human evolution made such wonderful progress.

In the present conditions and tendencies of the human race, in the contest between progressive and retrogressive forces, we see much cause for anxious concern, but thinking on the distant past and the boundless future creates a feeling of detachment and of philosophic calm like that of the dwellers on

Olympus. We cannot see clearly the next scene, we can scarcely imagine the next act, and the end of the great Drama of Evolution, if there is to be an end, is a matter of faith alone.

O, yet we trust that somehow good
Will be the final goal of ill,
To pangs of nature, sins of will,
Defects of doubt and taints of blood.

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INDEX

Abbott, Lewis, 22
Ability, intellectual, inherited trait, 171
Acceleration, prepubertal, 69
Acquired characteristics, inheritance of, 156-157
Acromegaly, 64
Actions, intelligent, 105, 119
  mechanical, 105
  reflex and instinctive, theory of the origin of, 107
  tropisms, 105
  volitional, 100
Activities, control of bodily, 84
Adams, Henry, 126, 128
Adaptation, intelligent, 106
Adaptive reactions, 113
Adjustment, automatic, 150
  cultural, 136
  Darwinian theory of, 126
  human, 134
  intelligent, 119, 150
  material, 133
  societal, 136
Adjustors, 84, 86
Africa, racial amalgamation in, 176
Age, Chellean, 22
  Mesozoic, 19
  of *Pithecanthropus,* 16
  Pliocene, 9
  Upper Siwalik, 16
Alimentary canal, development, 49
  organs developing from, 52
Alterations, chemical, in senescence, 71
Amalgamation of races, 175
Amalgamation, tendency to, 176
Ameghino, F., 10
American, typical, 175
Amnion, 57
Amniotic cavity, 43
Amœba, 105, 112, 153
Analogy, 129
Anatomical variations, 75-78
Animal, consciousness, theory of, 112
  fitness, 135
  intelligence, 104-112
  life, changes in, 104
  reactions, 121
  size, 63
  behavior of, 108
Animals, invertebrates, 39
  mammals, 39
  metazoa, 39
  protozoa, 39
  vertebrate, 39
Ant, instincts of, 108
Anthropophagy, 144
Anthropoids and man, Huxley's comparison, 131
  phylogeny, 36
Anti-bodies, see Hormones
Antiquity, means of determining, 8
Appendix, comparison of, in various animals, 74
  vermiform, 73, 74
Archipallium, 46, 93
Areas, association, of brain, 120
  frontal, of brain, 120
Aristotle, 81
Art, Aurignacian, 34
Art, Crô-Magnon, 32

Arteries, development, 52
hardening of, 70
Arteriosclerosis, 70
Asia, birthplace of mankind, 5
Association areas of brain, 120
Association, inheritance, 157, 163
Assortative mating, 169
Attica, New York, 11
Auricle, of heart, 51

Bacillus bulgaricus, 71
Bagehot, W., 145
Banderlog, the, 109
Banolas, Spain, 24
Bee, instincts of, 108
Behavior of animals, 108
of man, 120
instinctive, 105
intelligent, 110, 122
Bell, A. G., 172
Birds, nesting instincts of, 108
Birth, 60
Birth control, 172
effects of, 173
Birth-rate, 171-174
American scientists, 172
of college graduates, 171
of intellectual classes, 171-174
Phi Beta Kappa, 172
Birth, ratio to deaths, 174
Births, multiple, 62
proportion of male and female, 62
Blood cells, development, 52
natural history, 52
Blood vessels, development, 52
"Blue baby," 60
Blumenbach's classification, 40
Body cavity, see Cœlom
Body proportions, changes in during growth, 65
Body wall, formation of, 45
Bone, growth of, 67
growth shown by madder, 67
Bones, cranial, ossification of, 55
Boule, Marcelin, 24
Boy, growth of, 67-69
Brain cells, number in cortex, 93
Brain, cortex, 93, 120
Breuil, l'Abbé, 34
Broken Hill mine, Rhodesia, 28
Bronze, age of, 2
Bushmen, Africa, 12

Cæcum, 73, 74
comparison in various animals, 74
Cancer, 65
Cannibalism, 136, 144
Capacity, human, 122
Capacity, mental, dependent on inheritance factors, 171
Capillaries, development, 52
Carbon, 99
Catholicism, 144
Cattell, 172
Cavern, Lost Hope Inlet, 11
Celibacy, 169
Cells, 39
interstitial, 97
Cerebral cortex, 93
atrophy, 71
center of sensation, 82
Cerebral sacs, 45
Changes, retrogressive in various organs, 73-75
Characteristics, acquired, inheritance of, 156-157
of soma, 157
Child, change in proportions, 65
Chimpanzee, fossil, 20
Chorion, 57
Chronological table, 4
Chronology, European, 3
Churchward, A., 12
Circulation, change at birth, 60
Civilization, 115, 134, 158
European, 115
evidence of, 118
pre-Columbian, 11

Civilization, retrogressive selection of, 168-171
Clarke, Dr. J. M., 11
Classes, hereditary, 170
  intellectual, birth rate of, 171-174
Classification, of human races, 40
Cleft palate, 57
Coccyx, 77
Cochlea, 48
Code, new, of adjustment, 144
Codes, collision of, 144
  rational selection of, 146
Cœlom, 44
Collyer, 36
Combinations, Mendelian, 154, 155, 170
Competition, between societies, 143
  tragedies of, 145
Conduct, 134
  rational, 105
Congenital imperfection, 167
Consciousness, and experience, 113
  and intelligence, 112-114
Control, voluntary, lack of in certain actions, 106
Conversion, sexual, 97
Conviction, *ex parte,* 148
Cortex, of brain, 120
  cerebral, 93
Counter-selection, 135
Cranial sutures, disappearance of, 67
Creation, Mosaic account of, 1
Creeping, sea-anemone, 88
Cretinism, 64
Crô-Magnon man, 31
  art, 32
  decline, 35
  implements, 32
  size, 32
  skull, 32
  skull and face, 33
  skull, compared with Neandertal man, 25
Cultural adjustment, 135, 136
  societal, 135
Custom, 136

Darling Downs, Australia, 12
Darwin and modern science, 131
Darwin, C. R., 128, 131
  formulation of natural selection, 158
  on variation, 156
Darwinian factors, 130, 136
  theory, 131
Dawson, Charles, 20, *22*
Deaths, ratio to births, 174
Degeneracy in certain families, 168
Degeneration, senile, see Senescence
Dentition, 75
Dermis, 56
Descent of man, Darwin's, 129
Destiny, mankind, 165
Development, social, form of, 164
  early prenatal period, 42-45
  later prenatal, 45-63
  postnatal, 63-70
Differentiation, and extinction, 161
  relation to regeneration, 65
Diprothomo, 10
Discussion, Age of, Bagehot, 145
Drosophila, 155
Dubois, Dr. E., 13, 15
Düssel, Germany, *23*

Ear, development, 48
  vestigial muscles of, 73
Earthworm, nervous system, 85
East Anglia, England, 36
Ectoderm, 43
  derivatives from, 43
Education, eugenical, 179
Education, Henry Adams, 126
Education, importance of, 181
  in relation to mores, 142
Effect, coöperative, 165
Effectors, 85
  sea-anemone, 89

Egg cells, 96, 158
development, 42
fertilization, 41, 42
potency of, 153
Ehringsdorf, Germany, 24
Elements, chemical, freedom of action in living matter, 100
chemical, organized in nervous protoplasm, 100
of animal body, 99
Embryo, circulation, change at birth, 60
condition, at birth, 61
development *in utero*, 57
prenatal conditions, 60
Embryonic area, 43
Emotion, 146
Emotionalism, 163
Emotions, 118
Endocrine organs 49, 95
Endoderm, 43
derivatives from, 43
Environment and mutations, 156
Environment, diverse of man, 132
Eoanthropus dawsoni, 19-23
Eolithic period, 3
Eoliths, 3
Epidermis, 56
Eugenics, 170
importance of, 181
Eugenists, 148, 182
Evolution, and natural selection, 158
and progress, 127
direction of, 165
causes of, 153, 154
cycles in, 153
directions of, 159
drama of, 152
germ-plasm, 157
human, tendencies of, 179
intellectual, 162
main lines of, 161
of man, 155, 161, 162
only an adjustment, 127
neuromuscular system, 92
past, causes and directions of, 154-165
progress and retrogression, 127
progressive, 183
reversal of principle, 166
societal, different from that in nature, 136
Expedition, American Museum, 7, 12, 37
Experimentalists, animal, 110
Experimentation, animal difficulties of, 108-110
Experimentation, in relation to variations, 140
Extremities, phantasmal, 82
Eye, development, 48
Eyelid, vestigial, 72

Face, development of, 56
Factors, Darwinian, 130
individual, 154
Female, characteristics of, 96
Femur, development, 55
Fertilization, 41, 42
Feudalism, 136
Fishberg, 176
Fisher, Irving, 172
Fishes, spawning instincts of, 108
Fitness, animal, 135
in natural selection, 158
societal, 135
Flints, Foxhall, 36
giant of Cromer, 36
rostro-carinate, 36
"Fluctuations," 154
Foramen, ovale, 60
Fore-brain, 45
Forest beds, pre-Glacial, 19
Fossil man, Africa, 11
Asia, 12
Broken Hill mine, 12
conditions of preservation, 7

Crô-Magnon, 31-36
Dallas, Texas, 10
Dawn man, 19-23
Heidelberg, 16-19
Heidelberg, age, 19
intelligence of, 114
Lansing, 10
Mousterian, 23
Neandertal, 23-28
Nebraska loess, 10
Piltdown, 19
Piltdown, age of, 22
pre-Mousterian, 35
Rancho La Brea, 10
record of discovery, 9
South American, 10
Tertiary, 36
Upper Paleolithic, 31
Upper Pliocene, 36
Vero, Florida, 10
Foxhall flints, 4
Frank, T., 180
Freedom of mind, 101
Frog, 112
intelligence of, 111
Frontal, areas of brain, 120

Galley Hill skull, 35
Galton, F., 167, 169, 171
Geikie, 19
Genes, 154
Genial pit, 22
Genital organs, external, development of, 54
Germ cells, 157
Germany, champion of a code, 142
Germinal cells, union, 42
Germinal inheritance, 157
Germ-plasm, 154, 158, 163, 164, 171, 182
environment of, 156
evolution in, 157
Gill clefts, 49
Girl, growth of, 67-69
Gonads, development, 53
grafting, 71
migration, 54
producing sex cells and hormones, 97
Government, a cultural adjustment, 134
Gower, Wales, 31
Graduates, college, children of, 171
Gravel beds, Hastings, 19
Gravels, Piltdown, 19
Trenton, 10
Greece, decay of, 179
Gregory, W. K., 14, 16, 19, 22
Grimaldi, 34
features of, 34
relation to Bushmen, 34
Grotte des Enfants, France, 34
Ground sloth, 11
Growth, 63
bone, 67
curves for height and weight, 67
controlled by internal secretions, 64
decreasing rate of, 64
hereditary factor in, 64
period of, 64
relative rate of, in organs of body, 66
retarded by certain factors, 64
Grypotherium, 11
Guinea pigs, gonad transplantation in, 96

Habits, fixed, 107
Haeckel, 100
Hair, development, 56
fetal, 56, 77
regulation of development by hormones, 56
slopes, 56
tessellated junctions of, 56
Haldane, 102
Harelip, 57
Heart, auricles, 51

development, 50
ventricles, 51
Height, average of, 69
Helix, of ear, 73
Hermaphroditism, spurious, 53
Hernia, formation of, 53
Hind-brain, 45
Homo neandertalensis, 23-28
Homo (Palaeanthropus) heidelbergensis, 16-19
Homo primigenius, 23-28
Homo rhodesiensis, 28-31
Homo sapiens, 18, 31-36, 40
differentiation, 36
Grimaldi type, 34
Hormones, 50, 96, 157
effect upon personality, 95
of interstitial cells, 97
relation to nervous system, 95
see Internal secretion
Horse, evolution of, 9, 64
Hrdlička, A., 10
Human intelligence, 114-122
Human race, present conditions and tendencies, 165-179
Humerus, containing supracondylar foramen, 77
development, 55
Humors, 95
and Hormones, 95
Hunter, J., experiment of, 67
Huxley, T. H., 131, 156
Hybrids, 176
Hydrogen, 99, 101
Hypophysis, see Pituitary body

Ideographs, 2
Implements, Eolithic, 19, 22
Indian, North American, 116
Indo-China, amalgamation in, 176
Industries, Magdalenian, 12
pre-Crag, 36
table of, 4
Inferences, human, 121
Inguinal canal, 53
Inheritance, and variation, 153-156
social, 142, 157
factors and mental capacity, 171
germinal, 157
Instinct and reason, 105
Instinctive, actions, theory of the origin of, 107
manipulations, 119
Instincts, 106, 111
animal, 108
biological utility of, 106
hereditary, 106
Institutions, human, rise of, 138
Intellect, development of, 153
Intellectual power and cultural surroundings, 116
Intelligence, 122, 166
and consciousness, 112-114
and relation to nervous system, 119
animal, 104-112
evolutionary processes of, 112
frog, 111
function of nervous system, 104
future development of, 122-125
guinea pig, 111
human, 114-122
individual, field of, 119
prehistoric man, 114
primates, 111
rudimentary power of, 112
variation in human races, 115
Interest and emotion, 146
Intermarriage, 170
Internal secretion, development of organs, 49
influence of puberty, 69
see Hormones
Interstitial cells, 97
Intestine, appendix of, 73, 74
cæcum of, 73, 74
Intussusception, 63
Invention, an adjustment, 134
Inventions, great progress in, 164

Iron, age of, 2
Irrationalism, 163
"Ishmaels," 168
Isolation, geographical, lack of, 175
  racial, 174

Jacob's cavern, 11
Jaw, Heidelberg man, 16
  shrinkage of, 75
Jews, amalgamation of, 176
"Jukes," 168

Kaa, 109
"Kalikaks," 168
Keith, Sir A., 10, 11, 18, 20, 22, 26, 28, 30, 35, 36
Krapina, Austria, 24
Kultur, 159

Labor, division of, a mores, 137
La Chapelle-aux-Saints, France, 24
La Ferrassie, France, 24
La Naulette, Belgium, 24
La Quina, France, 24
Language, 118
  a mores, 137
  advantage of, to man, 118
  as a mores, 141
  man's control over, 120
  responsible for man's superiority, 120
Lanugo, 77
League of Nations, 128
Le Moustier, France, 24
Life-conditions, 139
Life cycle, 70
Lightfoot, John, 1
Limbs, development, 55
  pentadactyl, 55
Liver, development, 50
Lungs, development, 49

Magazine, *Natural History,* 11
Male, characteristics of, 96
Mammalia, Pleistocene, 12
Mammals, instincts of, 108
Mammary glands, supernumerary, 77
Man, ability to accustom to different environments, 133
  American, 40
  and anthropoids, 131
  behavior of, 120
  bodily evolution of, 162
  Caucasian, 40
  controlling his evolution, 166
  dispersal of, 6
  Ethiopian, 40
  evolution of, 155
  fossil, see Fossil man
  Java, see *Pithecanthropus,* 14
  Malay, 40
  Mongolian, 40
  Mongoloid, 11
  Neandertal, 14
  nervous system of, 84
  nervous system, summary of evolution in, 102
  New World, 11
  normal life cycle, 72
  phylogeny, 36
  Prehistoric, species, 13
  Primitive, language of, 118
  progressive, evolution of, 161-165
  races of, 38, 40
  similarity of, 132
  structural relations, 39
  structural unit of, 39
Manipulations, instinctive, 119
Mankind, birthplace of, 5
Mantle, 46
Marriage, 136, 147
  a cultural adjustment, 134
  hindered by modern conditions, 169
  productivity of, 169
Marshall, Alfred, 178
Mastodon, engraving of, 11
  remains of, 11

Mate selection, 169
Mating, assortative, 169
Mauer, Germany, 16
  sands, 16, 17
Maupas, theory of, 72
McGregor, J. H., 15, 18, 20
Mechanism, neuromuscular, 85
"Melting pot," 177
  Roman Empire, 180
Mendelian combinations, 154, 155, 170
  inheritance, 177
Mendelism, 154
Mental life, various factors which influence, 124
Metazoa, 39
Metchnikoff, theory of, 71
Mexico, racial amalgamation in, 176
Mesoderm, 43
  derivatives from, 43
Mid-brain, 45
Miller, G. S., Jr., 20
Minot, on differentiation, 161
  theory of, 72
Moir, J. Reid, 22
Momsen, 179
Mores, 137, 138, 139
  and education, 142
  and imitation, 141
  and life conditions, 138
  and sex, 138
  code of behavior, 147
  learned not inherited, 141
  transmitted by tradition, 141
Morgan, T. H., 155
Morula, 42
Mousterian industries, 3, 4
Mowgli, 109
Mulattoes, 176
Murals, cavern, 12
Muscle, *rectus*, 76
  sternalis, 76
  subtegumentary, 76
Muscles, development, 53
  effectors, 85
  shifting of position, 55
  vestigial, 73
Mutations, 154, 155
  and environment, 156
  directions of, 159
  their causes, 156
Myelin sheath, 47
Myotomes, 44

"Nams," 168
Nasal cavity, development of, 57
Natural law, 147
Natural sciences, future achievements in, 123
Natural selection, 135, 158, 178
  elimination of the unfit, 143, 166
Naturalists, observations of, 108-110
Neandertal man, anatomical features, 24
  ideas concerning, 28
  modern representatives of, 28
  skeleton, 23, 24
  skeleton compared with Crô-Magnon man, 25
Neolithic period, 2
Neopallium, 46, 93
Nerve cells, 46
  development, 49
  evolution, 49
  number in cortex, 93
  see Neurones
Nerves, afferent, 48
  motor, 46
  myelin sheath, 47
  sensory, 46
Nervous elements, lacking in sponges, 92
Nervous organization, sea-anemones, 86
Nervous system, adjustors, 84, 86
  and organization, 99
  and personality, 81-83
  and sex, 94-99

central, 84, 86
diffuse, 87
earthworm, 85
effect of interstitial secretions, 98
effectors, 85
in relation to intelligence, 104
influenced by environment, 95
intricate structure of, 84
man and higher animals, 84
organization, 84
receptors, 85
reflex mechanism, 47
rudiment, 44
summary of evolution in man, 102
sympathetic, 85
vertebrates, 93
Neural groove, 44
tube, 44
Neuromuscular mechanism, 85
Neuromuscular system, evolution of, 92
Neurones, 46
internuncial, 84
motor or efferent, 84, 85
see Nerve cells
sensory or afferent, 84, 85
New Zealand, mixed races, 176
Nitrogen, 99
Nose, development, 57
Notochord, 44
Nourishment of embryo, prenatal, 57

Obercassel, Germany, 32
Old age, see Senescence
Oldoway ravine, 11
Olfactory, archipallium, 93
cortex, 93
organ, development of, 57
organ, retrogression in, 73
pits, 57
Ontogeny, 52, 164
course of, 159
Organicism, 102
Organism, structural unit of, 39
Organization, 134
and a society, analogy between, 129
in relation to nervous system, 99-101
nervous, of sea-anemones, 86
sponges, 90-91
Organs of body, relative rate of growth, 66
Orthogenesis, 156
Osborn, H. F., 4, 18, 34, 35, 36
Ouse, Sussex, 19
Ovum, fertilization, 41, 42
structure, 42

Pacific Islands, racial amalgamation in, 176
Paleolithic period, 2
Pallium, 46
Pan vetus, 21
Pancreas, development, 51
Parables, 129
Parathyroid gland, development, 49
Parr, Thomas, 70
Particles, protoplasmic, 152
Pathways, hereditary, 106
Pearl, R., 174, 175, 178
Pech de l'Azé, France, 24
Perception, sense, 116
Personality, and nervous system, 81-83
influence of sex glands upon, 98
Phantasms, 145
Phylogeny, 52, 164
course of, 159
provisional, of man and anthropoids, 36
Pineville, Missouri, 11
Pithecanthropus erectus, 12-16
Pituitary body, development, 49
Placenta, development, 58
filter against bacteria, 59
intervillous spaces, 58
osmosis in, 58
passage of materials through, 58-60
separation of fetal and maternal blood, 58

villi, 58
Pleistocene, 8, 10, 17, 22, 36
Plica semilunaris, 73
Pliocene, 16
Polydactylism, 55
Pomace fly, 155
Population, and subsistence, 178
effect, of the world, 178
foreign-born birth-rate, 174
limits of, 178-179
maximum, 178
native birth-rate, 174
negro, of United States, 176
South American countries, 176
United States, 178
Postnatal retardation, 68
Prepubertal acceleration, 69
Primary germ layers, 43
Primates, intelligence of, 111
Primitive streak, 43
Processes, rational, 111
selective, 143
Products, cultural, 134
Progress and evolution, 127
due to specialization and coöperation, 160
definition of, 159-160
limits of, 160-161
Propagation, by selection, 170
Proportions of body, changes in during life, 65
Protestantism, 144
Protoplasm, primeval, 152
Protozoa, 39
Puberty, 69
influenced by internal secretion, 69
Pygmies, 5

Race, composite, characteristics of, 177
differentiation and amalgamation, 174-178
mixtures, 175
Race suicide, 135
Roman Empire, 180
Races, blending of, 176
difference in intelligence, 115
primary, of mankind, 176
Racial isolation, 174
Rational, conduct, 105
processes, 111
Reactions, adaptive, 113
animal, acquiring of, 121
reflex, 106
spontaneous, 107
summary of, in various animals, 111
tropistic, 113
Realm, societal, elemental forces in, 149
Reason and instinct, 105
Recapitulation, Law of, 52
Receptors, 85
sea-anemone, 89
Recombinations, 154
Reflex actions, 106
theory of the origin of, 107
Regeneration, in amphibia, 65
in man, 65
power of, 65
Rejuvenescence, 71
Religion, 136, 147
evolution of, 123
Reproductive system, development, 53
Retardation, postnatal, 68
Retrogression, 73-75
Rhodesia, Broken Hill mine, 12
Rhodesian man, 28-31
skull, 30
Ribs, variation in number, 75
Roman Empire, race suicide, 180
Rome, decay of, 179
Rubner, 72
Rutot, A., 4

Schoetensack, Dr. O., 16, 19
Science and religion, 144
Sea-anemone, creeping, 88
effect of stimulation, 86
effectors, 89

feeding of, 87, 88
nervous organization, 86
receptors, 89
sense organs, 90
structure, 86
tentacle, effect of detaching, 87
Secretions, interstitial, effect on nervous system, 98
Segments, 44
Segregation, 170
Selection, 130, 143
a negative process, 143
ordinary, improvement by, 148
essential processes of, 143
Selenka, Madame, 13
Self-direction, 146
Self-maintenance, 137
Senescence, 70-72
theories of, 71
Senile degeneration, see Senescence
Sensation, 82
Sensations, primitive, 101
Sense organs, retrogressive changes in, 73
sea-anemone, 90
Sense perception, 116
Sensorium commune, 81
Sex and nervous system, 94-99
Sex, cause of, 62
center of society, 98
conditions, indifferent, 53
definition of, 95
determination before birth, 62
glands, see Gonads
reversal of, by gonad transplantation, 96
transformation of, 96
Sextuplets, 62
Sexual characteristics, determined by gonad, 97
primary, 96
secondary, 96, 97
secondary, controlled by gonad, 97
Shere Khan, 109
Skeleton, cartilage, 55
development, 55
membrane, 55
Skin, development, 56
Skull, Calaveras, 9
cap, *Pithecanthropus,* 13, 14
Gibraltar, 23
pre-Neandertal, 18
Slavery, an adjustment, 128
Smith, Elliot, 20
"Social theory," 151
Societal, adjustment, 136
code, 139
evolution, past processes, 149
fitness, 135
range, forces at work, 150
realm, 149
selection, in relation to war, 144
selection, various forms taken by, 145
Societies, struggle of, 143
Society, and organisms, analogy between, 129
human, changes in, 163
relation of to sex, 98
stratification of, 170
systems, cultural adjustments, 134
Sollas, W. J., 12, 34
Specialization, and progress, 160
relation to regeneration, 65
Spencer, H., 129
Sperm cells, 95
in fertilization, 42
structure, 42
Spider, instincts of, 108
Sponges, 90-92
lack of nervous tissue, 92
Spy, Belgium, 23
Steinach, 71, 97, 98
gonad transplantation, 96
Stimulation, effect of, in sea-anemones, 87

Stone, age of, 2
Sumner, W. G., 137, 139
Superstition, 163
Supracondylar foramen, 77
Survival of the fittest, 143
Sympathetic system, 85

Tail, in man, 77
Tariff, protective, 128
Tasmanians, 3
Teeth, cynodont, 14
  decay, 75
  dentine, 57
  development, 57
  enamel, 57
  first set, 67
  fourth molar, 76
  Heidelberg man, 18
  permanent, 67
  pulp, 57
  retrogressive changes, 74
  taurodont, 14
Tendency, tropistic, 106
Tentacle, sea-anemone, 87
Tests, psychological, American Army, 117
Tetraprothomo, 10
Thames gravels, 35
Thymus glands, development, 49
  fate of, 50
  migration, 50
Thyroid glands, development, 49
  migration, 50
Tools, not used by lower animals, 118
"Trial and error," 158
Transmission, of mores by tradition, 141
Transplantation, gonad, 96
Trinil, Java, 12, 13
Tropisms, 105, 106
Tubercle, Darwin's, of ear, 73

Urinary system, development in relation to genital system, 53
Uterus, contractions at birth, 60
  digestion of wall by embryonic cells, 58

Variation, 130, 139
  accidental, in relation to reflexes, 107
  anatomical, 75-77
  and experimentation, 140
  and inheritance, 154-156
  and the world-code, 142
  depend upon verification, 140
  environmental, 154
  rational, 140
Vas deferens, 71
Vascular system, development, 51
Veins, development, 53
Ventricles, 51
Vermiform appendix, 73, 74
Vertebral column, 44
Vestigial structures, 72-75
Villi, of placenta, 58
"Vital index," 174
Volition, 107
Volitional actions, 100

War, and retrogressive selection, 168
  form of societal selection, 144
Water, 101
  currents, in sponges, 91
  percentage, in body, 64
Weight, average, 69
  increase in prenatal development, 63
Weismann, theory of, 71
West Indies, racial amalgamation in, 176
Woodward, Smith, 20, 30
World-code and variations, 142

Yale Babylonian Collection, 2
Yolk sac, 43, 44

"Zeros," 168

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